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UNIVERSITY OF MINNESOTA.

Agricultural Experiment Station.

BULLETIN No. 19.

MARCH, 1892.

DEHORNING EXPERIMENT.

CREAM RAISING BY COLD DEEP SETTING.

EXPERIMENTS IN CHEESE MAKING—INCORPORATING CREAM INTO CHEESE, ETC.

THE BABCOCK TEST AND CHURN.

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DEHORNING EXPERIMENT.

CLINTON D. SMITH AND T. L. HÆCKER.

Last summer it was decided by the Regents to place upon the station farm, a herd of good dairy cows, selected from natives, thorough-breds and their grades. In carrying out this purpose, some twenty-five cows were purchased during the month of October and shipped to the station. When they were let into the yard, it was noticed that the larger cows drove the smaller from feed and water, and often prevented their drinking unless protected by the attendant. It was apparent, that unless some means could be devised to prevent this, serious losses would occur, from irregular feeding and drinking and by premature births.

It was decided that the quickest and most effectual remedy was dehorning. This is, by many, considered a questionable practice, because of the pain inflicted during the operation. In order that the immediate effects might be studied, a comparison was made of the daily yield of milk and per cent of fat, before and after dehorning. These results were compared with the record of a number of cows, not dehorned but which saw the operation and smelled the blood.

The cows, Franc, Roxy, Sully, Gran, Clara and Crossy were over five years old and Patsey, Rossie and Bettie, over four years; these were dehorned on the ninth of November, 1891. They were fastened in a stanchion, the head drawn forward by means of a halter and small tackle blocks, until the neck was extended to its full length, so that the horns were sufficiently far from the stanchion to permit the free use of the narrow bladed butcher's saw, which we used.

The time occupied was about five seconds per horn; as soon as the horns were removed, pieces of cotton cloth smeared with pine tar were placed upon the wounds. Care was taken to saw the horns inside of the outer edge of the skin, removing with the horn a narrow strip of hair.

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During the operation the cows gave every indication of intense suffering; but, upon being released no sign of pain was visible. The wounds healed rapidly without any other application than the tar.

Table I. is taken from the regular herd record, showing the pounds of milk given by each cow for the three milkings before they were dehorned, the per cent fat and total fat.

TABLE I.

	First Milking.			Second Milking.			Third Milking.		
	Lbs. milk.	Per cent fat.	Total fat.	Lbs. milk.	Per cent fat.	Total fat.	Lbs. milk.	Per cent fat.	Total fat.
Betty...	11.5	4.3	.494	11.	3.8	.418	11.5	4.1	.471
Clara...	9.5	4.6	.437	9.	3.7	.333	7.1	4.	.284
Crossy.	6.5	4.7	.305	6.5	4.9	.318	6.5	4.4	.286
Franc..	13.5	3.9	.526	13.5	4.	.540	15.	3.6	.540
Gran....	10.	3.8	.380	9.25	3.4	.314	9.5	4.3	.408
Patsey	10.5	3.5	.387	11.	3.6	.396	11.25	4.	.450
Rossie..	10.9	4.2	.457	10.	3.3	.330	10.9	3.7	.403
Roxy...	13.9	4.1	.569	12.75	3.5	.446	13.5	3.9	.526
Sully....	21.	4.5	.945	20.	4.3	.860	20.75	4.	.830
	107.3		4.5	103.		3.955	106.		4.298

Total milk yield for three milkings, 316.3.
Total pounds of fat for three milkings, 12.753.

Table II shows the pounds of milk given by each cow during the three milkings immediately following dehorning, with per cent of fat and total fat.

TABLE II.

	First Milking.			Second Milking.			Third Milking.		
	Lbs. milk.	Per cent fat.	Lbs. fat.	Lbs. milk.	Per cent fat.	Lbs. fat.	Lbs. milk.	Per cent fat.	Lbs. fat.
Betty...	10.6	2.9	.307	11.5	4.3	.495	9.25	4.6	.426
Clara...	12.25	7.	.857	9.	5.5	.495	9.25	4.7	.435
Crossy.	5.5	5.5	.302	6.	6.1	.366	6.5	5.9	.383
Franc..	12.75	3.4	.433	13.	3.9	.507	13.5	4.3	.580
Gran....	9.5	2.7	.256	7.5	3.8	.285	8.5	4.7	.400
Patsey.	10.	4.	.400	10.5	3.1	.325	10.5	3.8	.399
Rossie..	9.	3.2	.288	9.75	3.8	.370	9.25	3.7	.342
Roxy...	11.	4.6	.506	11.	4.8	.528	11.75	4.3	.505
Sully....	19.	3.1	.589	19.75	4.	.790	20.	3.6	.720
	97.6		3.938	98.		4.161	98.5		4.190

Total pounds of milk for the three milkings, 294.1.
Total pounds of fat for the three milkings, 12.289.

Table III shows the pounds of milk given by the six cows not dehorned, covering the same period as Table I, with per cent fat and total fat.

TABLE III.

	First Milking.			Second Milking.			Third Milking.		
	Lbs. milk.	Per cent fat.	Lbs. fat.	Lbs. milk.	Per cent fat.	Lbs. fat.	Lbs. milk.	Per cent fat.	Lbs. fat.
Gertie....	7.7	5.	.385	7.75	4.7	.364	8.	4.8	.384
Houston	15.5	5.1	.790	12.75	4.8	.612	13.25	4.9	.649
Maria....	13.	4.7	.611	13.5	4.7	.634	12.5	4.6	.575
Pottie....	12.75	5.	.637	12.25	4.	.490	12.1	4.5	.545
Pride.....	6.4	6.9	.441	5.5	5.6	.308	5.75	5 3	.305
Tricksey	13.25	5.1	.676	12.25	4.9	.600	12.25	5.5	.674
	68.6		3.540	64.		3.008	63.85		3.132

Total pounds of milk for the three milkings, 196.45.
Total pounds of fat for the three milkings, 9.68.

Table IV shows the pounds of milk given by the six cows not dehorned, covering the same period as Table II, the per cent fat and total fat.

TABLE IV.

	First Milking.			Second Milking.			Third Milking.		
	Lbs. milk.	Per cent fat	Lbs. fat.	Lbs. milk.	Per cent fat.	Lbs. fat.	Lbs. milk.	Per cent fat.	Lbs. fat.
Gertie....	7.	3.9	.273	8.25	6.	.495	7.5	4.9	.367
Houston	11.5	3.5	.402	15.5	5.2	.806	13.	5.3	.689
Maria....	12.	4.3	.516	13.5	4.8	.648	13.	4.6	.598
Pottie....	11.5	3.8	.437	12.75	4.3	.548	12.5	4.2	.525
Pride.....	6.	4.8	.288	5.75	5.4	.301	5.5	5.8	.319
Tricksey	11.5	3.7	.425	12.	4.3	.516	11.5	4.8	.552
	59.5		2.341	67.75		3.314	63.		3.050

Total pounds of milk for the three milkings, 190.25.
Total pounds of fat for the three milkings, 8.605.

In Table V. the first period has reference to the time covered by the three milkings immediately prior to dehorning and the second period, to the three milkings after dehorning.

TABLE V.

SUMMARY.

	Nine cows dehorned.	Six cows not dehorned.
Milk yield first period	316.3	196.45
Milk yield second period	294.1	190.25
Shrinkage of milk during second period	22.2	6.2
Per cent of shrinkage in milk	7.	3.
Yield of fat in lbs. first period	12.753	9.68
Yield of fat in lbs. second period	12.289	8.60
Shrinkage in lbs., fat	.464	1.08
Per cent of shrinkage in fat	3.	11.

By comparing the yield of milk of the cows dehorned with that of the cows not dehorned, it will be observed that the former gave 22.2 lbs less, during the three milkings after being dehorned, the latter losing 6.2 lbs. The dehorned cows shrinking seven per cent, while the others lost three per cent.

Comparing the total fat products of these two groups of cows for the same periods, we find a much greater discrepancy, the dehorned cows showing a shrinkage of only three per cent, while the six cows not dehorned lost eleven per cent. It would appear from these observations that while the operation of dehorning may cause a slight, temporary variation in the flow of milk and fat content, the normal flow and per cent of fat is quickly recovered, and, that cows only seeing the operation and smelling the blood show a greater shrinkage in fat than do the ones dehorned.

A DOUBLE MONSTROSITY OF A CALF TRACEABLE TO INJURY OF ITS MOTHER.

PROF. OLAF SCHWARZKOPF.

Early in October, 1890, David Porter, in charge of the cattle-barn of the Minnesota Agricultural Experiment Station, called me to see a Holstein-Friesian cow which was hit by the horns of another cow, a noted fighter, while passing into the stables. I found the cow very nervous and excited; on the right flank behind the last rib and about one foot below the loins was a small bruise, about as large as a fifty cent piece. As the cow was with calf I auscultated the uterus, but could find nothing abnormal. I instructed the man to keep the cow in a quiet place and to watch her as she might possibly abort, however, she soon seemed all right and nothing further was thought of the case.

On January 28, 1891, the cow dropped a calf; as it did not have any passages within two days the cattle-man gave it a dose of castor oil, which had no effect. He then reported it to me and also stated that the calf seemed to be crippled. In looking at the calf I observed at once that it had a curved spine and further examination revealed that there was no rectal opening.

I had the calf sent over to the veterinary hospital and on February 2, 1891, examined it. An incision was made where the natural opening should be, but after perforating the skin, no rectum was found but a direct entrance into the abdomen. The intestines that lodged in the pelvic cavity apparently were the colon or coecum. I tried hard to find the rectum but did not succeed. On February 3, the calf which was greatly emaciated, died. The post mortem examination showed the following:

On opening the abdomen an irregular situs of the intestines was first to be noticed; in removing the intestines I found the rectum near the liver, ending in a blind sack, curved and possessing a kind of nodule, resembling somewhat a

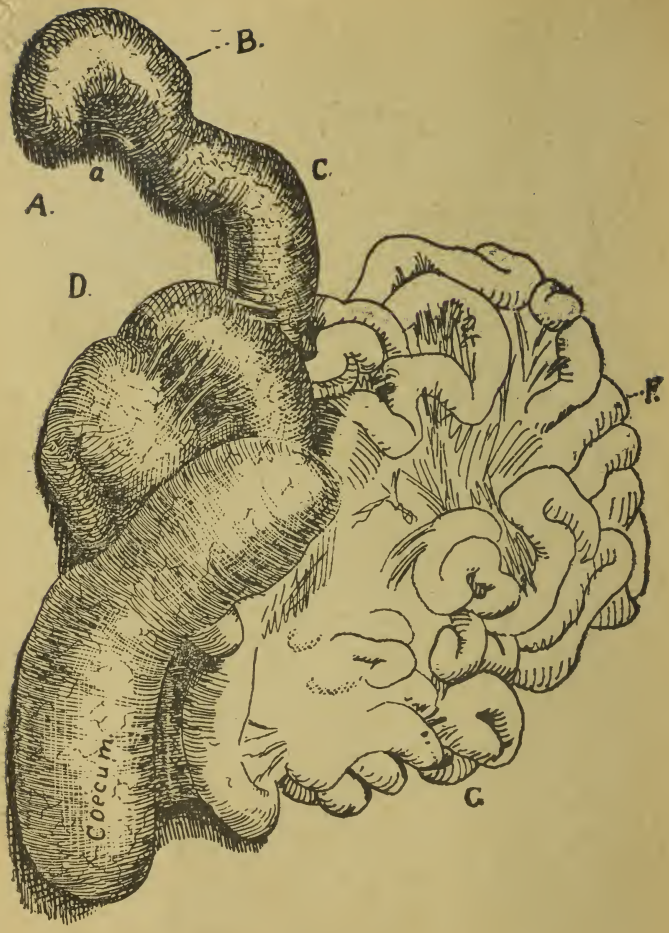

FIG. I.

A, Blind end of rectum; a, cicatrix; B, C, D, colon; F, ileum; G, jejunum.

cicatrix. After the removal of the intestines the the curve of the spine to the left was very apparent and the left kidney was very small and situated on top of the right kidney. The other organs were normal. The calf, certainly, could not have lived.

The practical conclusion that must be drawn from this case is that the abnormalities which the calf presented, were produced by external injuries. Critics may object and say that

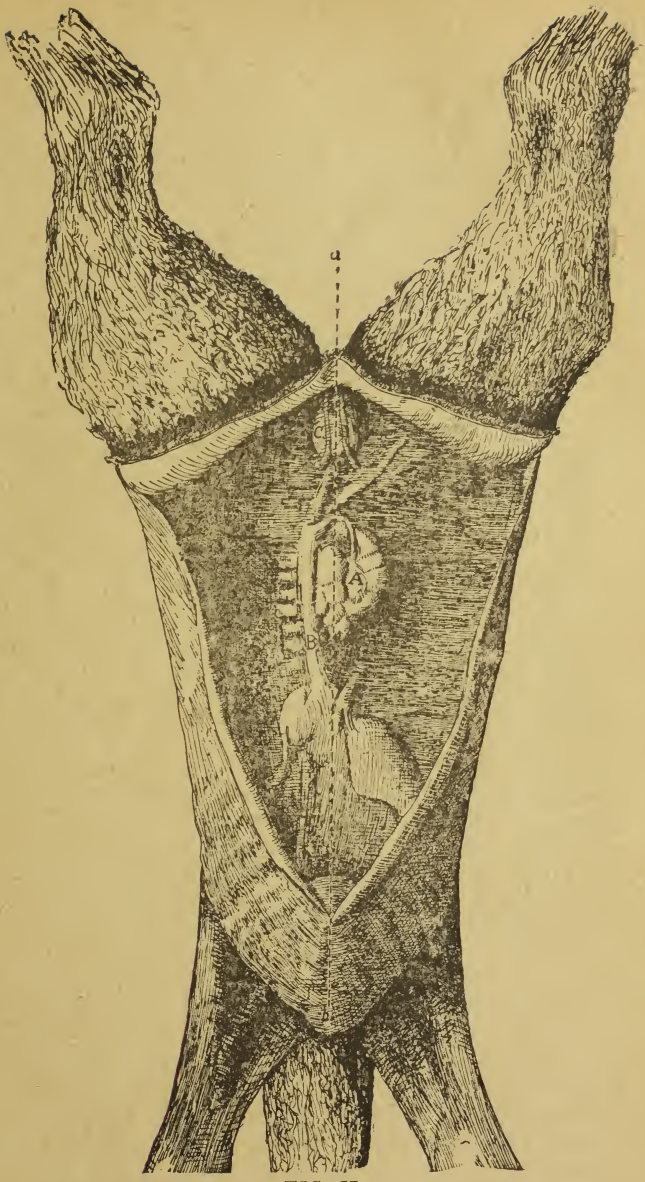

FIG. II.

A, right and left kidney in one place; B, posterior aorta; C, urinary bladder; a———b, straight line showing aberration of spine.

the skin and the membranes of the uterus are so thick that a cow's horn cannot touch the fœtus. This may be true as a rule, but by anyone that had examined this case, together with its history, no other conclusion could possibly be reached than to ascribe the cause of the abnormalities of the calf to the blow which its mother received four months previous to the birth.

I am not at all blindly devoted to dehorning cattle, on the contrary, being a lover of pure types and natural forms, I have always maintained that it is a violence of the laws of ethics and aesthetics to disfigure a beautiful Jersey cow by dehorning. But the principles of ethics are often out of place in the cow stable and barn-yard and I confess that I am now convinced, that it is a righteous and humane act to take horns off—at least of those cows that cannot keep peace with their fellow creatures.

CREAM RAISING BY COLD DEEP SETTING.

THE RAPIDITY OF THE PROCESS AND ITS RELATION TO THE TEMPERATURE OF THE SURROUNDING WATER.

HARRY SNYDER.

When milk is creamed by the cold deep setting system with the temperature of the tank water reduced to 39°-44° Ft. the efficiency of the creaming process is well known, but the changes that take place especially during the first part of the creaming process are not so well known. When the milk is set in the tank these questions are naturally suggested: How long before any change takes place; in which section of the can (top, middle or bottom) does the first change, in either temperature or fat content, occur; throughout the entire process what relationship exists between the rate of creaming of the different sections and the temperatures; and at the time of skimming how do the different sections compare as to the percentages of fat remaining in them?

In studying these questions the first difficulty that presents itself is the method of taking the sample from the can while the creaming process is going on without introducing a serious factor of error in disturbing the natural process.

Various methods of sampling were studied. Small glass siphons were at first made use of, but this method of sampling removed too much milk from the can, since a quantity of milk at least equal to the capacity of the siphons must first be removed before taking a sample. The method that gave the best results, and the one used in this experiment, is as follows: Two holes were bored in a block of wood and perforated corks fitted into these holes; through these perforations of the corks, glass tubes were passed, reaching to

the bottom and middle sections of the can. The block of wood rested on the top of the can and at the top end of each glass tube a piece of rubber, three inches in length was attached, furnished with a pinch cock which prevented the milk in the tubes from flowing back and causing unnecessary currents; the samples were taken by attaching a large pipette to the rubber at the end of the glass tubes opening the pinch cock and applying suction. A small measured portion equivalent to the capacity of the tubes was first removed before sampling. During the first trials another can of the same milk was set under precisely the same conditions and sampled only at the beginning and at the close of the trial periods, the object being to determine the effect of the slight currents caused by taking the samples in the way described. The figures given in the following tables are the averages of duplicate analyses. The temperature of the water in the various trials is somewhat higher than that required for the very best results, but inasmuch as many of the springs of the state which are used for this purpose are about the temperatures indicated, and some much higher, these temperatures were adopted so as to conform to about the normal conditions of many of the creameries of the state. The section designated as top was taken three inches from the surface, usually just below the cream line, but occasionally not, as the high per centages of fat in the results indicate.

In the following tables I, II, III and IV the changes that take place from period to period, under the conditions named may be studied:

TABLE I.

Milk divided into two equal portions set at 90° in water at 40°; 5% Fat in the original milk.

CAN I.				CAN II.			
Section of can.	Time from setting.	Per cent. fats.	Temp. of sections.	Section of can.	Time from setting.	Per cent. fats.	Temp. of sections.
Top	15 minutes	5.00	78 deg.	Top	15 minutes	5.00	72 deg.
Middle	do	5.00	72 "	Middle	do	5.00	69 "
Bottom	do	4.80	57 "	Bottom	do	4.95	56 "
Top	30 minutes	4.60	60 "	Top	30 minutes	4.95	60 "
Middle	do	4.45	57 "	Middle	do	4.90	57 "
Bottom	do	3.40	50 "	Bottom	do	3.60	49 "
Top	1 hour	4.00	54 "	Top	1 hour	3.40	54 "
Middle	do	3.85	52 "	Middle	do	3.20	52 "
Bottom	do	1.30	46 "	Bottom	do	1.95	46 "
Top	2 hours	3.30	52 "	Top	2 hours	3.60	50 "
Middle	do	2.10	46 "	Middle	do	3.00	47 "
Bottom	do	0.75	42 "	Bottom	do	1.05	42 "
Top	4 hours	1.45	46 "	Top	4 hours	1.55	45 "
Middle	do	1.35	45 "	Middle	do	1.35	45 "
Bottom	do	0.75	42 "	Bottom	do	0.65	41 "
Top	5½ hours	1.40	45 "	Top	5½ hours	1.20	45 "
Middle	do	1.00	44 "	Middle	do	1.10	45 "
Bottom	do	0.35	42 "	Bottom	do	0.55	43
Top	36 hours	0.40	44 "	Top	36 hours	0.50	44 "
Middle	do	0.30	44 "	Middle	do	0.45	44 "
Bottom	do	0.20	44 "	Bottom	do	0.20	44 "

Average of all sections, .30 fat. Fat in the skim milk, .35%.

Average for 36 hours, 38% fat. Fat in skim milk, 35%.

In Can B the middle layer was taken 1½ inches higher than in can A.

TABLE II.

CAN III. Set at 84° in water at 47°. 4.30 per cent. fat in original setting. Temperature at close, 47°.

SECTION OF CAN.	TIME FROM SETTING.	PER CENT. FATS.	NOTES.
Top	1 hour	4.1	
Middle	"	4.	
Bottom	"	2.05	
Top	2 hours	2.45	
Middle	"	1.65	
Bottom	"	.9	
Top	3 hours	2.05	
Middle	"	1.45	
Bottom	"	.65	
Top	4 hours	——	
Middle	"	1.2	
Bottom	"	.60	
Top	5 hours	1.45	
Middle	"	1.00	
Bottom	"	.3	
Top	8 hours	——	
Middle	"	.55	
Bottom	"	.35	
Top	11 hours	.50	
Middle	"	.30	
Bottom	"	.20	

The average of all sections at the 11-hour period was .33% fat. The per cent of fat in the skim milk was .30% at the close of 24 hours.

At the same time a duplicate can was set, and the fat in the skim milk was .30% at the close of 24 hours.

CAN IV. Set at 92° in water at 47°. 4.2 per cent. fat in original setting. Temperature at close, 46°.

SECTION OF CAN.	TIME FROM SETTING.	PER CENT. FATS.	NOTES
Middle	20 minutes	4.6	
Bottom	do	3.7	
Middle	40 minutes	3.60	
Bottom	do	1.50	
Middle	1 hour	3.40	
Bottom	do	.70	
Middle	1⅓ hours	3.50	
Bottom	do	.60	
Middle	1⅔ hours	2.05	
Bottom	do	.50	
Middle	2 hours	1.00	
Bottom	do	.50	
Middle	3½ hours	.90	
Bottom	do	.30	
Middle	5 hours	.5	
Bottom	do	.3	
Middle	6 hours	.45	
Bottom	do	.3	
Middle	7 hours	.40	
Bottom	do	.25	
Middle	8 hours	.40	
Bottom	do	.18	
Top	10 hours	.40	
Middle	do	.30	
Bottom	do	.15	

Average of sections at close, .28% fat.

The points to be noted in these tables are as follows:

1. The first and most marked action affecting the composition and temperature takes place in the bottom layer, and within fifteen minutes this layer will show a less per cent of fat; the temperature of the middle section is affected more slowly and suffers a less loss of fat.

2. The top section, when the action is very rapid, may at the first hour period, contain more fat than in the original milk, but as the period increases it, too, grows poorer.

3. In each of the corresponding periods, the top layer is always richer in fat than the middle layer, the middle layer is richer than the bottom, and the bottom layer is always the poorest. During the first five or six hours the same relationship exists as to temperatures. The middle section has an intermediate temperature between the bottom and top sections, which are respectively the lowest and highest.

4. At the time of skimming the same relationship of the different sections as to fat exists. This emphasizes the

TABLE III.

CAN V. Set at 82° in water at 48°. 4.05 per cent. fat in original milk.

SECTION. OF CAN.	TIME FROM SETTING.	PER CENT. FATS.	NOTES.
Top	15 minutes	3.9	
Middle	do	3.9	
Bottom	do	3.65	
Top	45 minutes	3.15	
Middle	do	3.00	
Bottom	do	1.20	
Top	2¼ hours	2.05	
Middle	do	1.05	
Bottom	do	1.00	
Top	4½ hours	.65	
Middle	do	.55	
Bottom	do	.50	
Top	6¼ hours	.65	
Middle	do	.45	
Bottom	do	.40	
Top	8¼ hours	.50	
Middle	do	.40	
Bottom	do	.20	
Top	10¼ hours	.40	
Middle	do	.30	
Bottom	do	.20	
Top	24 hours	.40	
Middle	do	.30	
Bottom	do	.15	

Average of all sections at the close of 10¼ hour period, .30; 24-hour period, .28.

CAN VI. Set at 90° in water at 43°.

SECTION OF CAN.	TIME FROM SETTING.	PER CENT. FATS.	TEMP OF SECT'NS IN CAN.
Top	at starting	3.70	90 deg.
Middle	do	3.65	90 "
Bottom	do	3.65	90 "
Top	1 hour	5.40	58 "
Middle	do	3.30	54 "
Bottom	do	1.00	52 "
Top	2 hours	4.00	55 "
Middle	do	1.25	52 "
Bottom	do	.50	48 "
Top	3 hours	1.80	52 "
Middle	do	.75	51 "
Bottom	do	.45	46 "
Top	5 hours	.75	47 "
Middle	do	.45	46 "
Bottom	do	.30	45 "
Top	7 hours	.45	46 "
Middle	do	.45	46 "
Bottom	do	.30	45 "
Top	10 hours	.45	44 "
Middle	do	.40	44 "
Bottom	do	.25	44 "
Top	13 hours	.45	.....
Middle	do	.40	.....
Bottom	do	.25	.....

Average of all sections at the end of 10-hour period, .37 fat; at the end of 13-hour period, .37 fat.

fact that samples of skim milk for analysis must be well mixed in order to obtain a sample that will represent the average composition, and at no time can a portion be withdrawn from any section and the fat in the whole skim milk calculated from the sample so taken.

TABLE IV.

CAN A. Set at 93° in water at 47°. 5.00 per cent fat in original setting. Temperature at close, 46°.				CAN B. Set at 90° in Water at 47°. 4.15 per cent. fat in original setting. Temperature at close, 46°.			
SECTION OF CAN.	TIME FROM SETTING.	PER CENT. FATS.	NOTES.	SECTION OF CAN.	TIME FROM SETTING.	PER CENT. FATS.	NOTES
Top	20 minutes	5.00		Top	15 minutes	4.15	
Middle	do	5.00		Middle	do	4.10	
Bottom	do	3.60		Bottom	do	3.95	
Top	40 minutes	2.55		Top	30 minutes	3.75	
Middle	do	2.25		Middle	do	3.50	
Bottom	do	2.00		Bottom	do	3.45	
Top	1 hour	(6.50)		Top	45 minutes	4.20	
Middle	do	2.20		Middle	do	4.10	
Bottom	do	1.60		Bottom	do	2.15	
Top	1⅓ hours	(7.50)		Top	1 hour	4.3	
Middle	do	2.10		Middle	do	4.05	
Bottom	do	1.50		Bottom	do	1.00	
Top	1⅔ hours	(10.60)		Top	1¼ hours	5.5	
Middle	do	2.00		Middle	do	3.8	
Bottom	do	1.40		Bottom	do	.8	
Top	2 hours	(10.00)		Top	1¾ hours	6.5	
Middle	do	2.00		Middle	do	2.65	
Bottom	do	1.10		Bottom	do	.45	
Top	2½ hours	1.90		Top	2¼ hours	9.5	
Middle	do	1.60		Middle	do	1.3	
Bottom	do	1.10		Bottom	do	.40	
Top	3¼ hours	1.60		Top	2¾ hours	4.55	
Middle	do	1.50		Middle	do	1.3	
Bottom	do	.70		Bottom	do	.40	
Top	4½ hours	1.50		Top	3¾ hours	.75	
Middle	do	1.30		Middle	do	.7	
Bottom	do	.60		Bottom	do	.4	
Top	6 hours	1.10		Top	4¾ hours	.5	
Middle	do	1.00		Middle	do	.48	
Bottom	do	.45		Bottom	do	.40	
Top	7½ hours	1.10		Top	5¾ hours	.50	
Middle	do	.60		Middle	do	.40	
Bottom	do	.30		Bottom	do	.30	
Top	9½ hours	.90		Top	7¾ hours	(Lost.)	
Middle	do	.60		Middle	do	.30	
Bottom	do	.20		Bottom	do	.15	
Top	11½ hours	.50		Top	9¾ hours	.40	
Middle	do	.30		Middle	do	.30	
Bottom	do	.20		Bottom	do	.15	

The duplicate of this can sampled at the close of the 12½-hour period..... Top .50, Mid. .25, Bot. .15 } Average .30.

The duplicate of this can sampled at the close of the 9¾ hour period showed..... Top .30, Mid. .30, Bot. .15 } Average .25

12½ hrs.—top .50
do —mid. .30 } Average .33.
do —bot. .20

Average of Sections at Close of 9¾ hours, .28 per cent.

5. The temperature of the water at the time of setting is of far greater importance than the temperature of the milk. A reduction of 10° in the temperature of the milk does not appreciably affect the result, while a difference of

less than half of this amount in the temperature of the tank water seriously effects the creaming. When the temperature of the tank water is reduced to 40°, about 5 hours time is required for the different sections to attain a constant temperature and it is to be observed that during this period the most of the fat is brought to the surface and that during all of this period there is a constant relation between the fall in temperature and fat, the most rapid change in each section being observed when the temperature of that section reaches the temperature of the surrounding water. What the cause of this close relationship is, no satisfactory explanation has yet been given, simply the fact is known and the dairyman must conform to these temperatures in order to obtain the most beneficial results.

Since this is the season of the year when ice can be stored so abundantly and at little expense every dairyman is urged to lay in a supply. A running spring with a temperature not higher than 48° will do effectual work, but with temperature from 50° to 60° the creaming of milk by this process is attended with serious losses of fat in the skim milk. By the use of ice at least eight pounds of butter can be made where less than seven pounds are produced without it. When milk is set at temperatures as indicated in previous tables the usual practice is to skim at the end of eleven hours in order to use the pails and creamer for the next milking; this is a practice entirely safe with this system of creaming, under proper conditions. The average length of time required for the practical completion of the creaming of the above samples was only nine and three-quarter hours. A similar study of milks that cream less perfectly and under less favorable conditions was made in order to obtain data as to the length of time necessary for the completion of the creaming.

HOW LONG BEFORE SKIMMING CAN SAFELY BE DONE.

In the following table is an example of a can of milk set at 90° in a tank of water at 60°, which is a very unfavorable condition for creaming, the results show how slow and imperfect the action when compared with a lower and more favorable temperature and also how the rising of the fat practically ceases at about the eleven hour period.

TABLE V. CAN 7.

Section of Can.	Time From Setting.	Per Ct. of Fat.	Section of Can.	Time From Setting.	Per Ct. of Fat.
Top	at setting		Top	6¼ hours	3.00
Middle	do	4.45	Middle	do	2.70
Bottom	do		Bottom	do	2.25
Top	15 minutes	4.48	Top	7½ hours	2.78
Middle	do	4.5	Middle	do	2.65
Bottom	do	4.48	Bottom	do	2.20
Top	30 minutes	4.5	Top	8¼ hours	2.70
Middle	do	4.4	Middle	do	2.45
Bottom	do	4.45	Bottom	do	1.60
Top	45 minutes	lost	Top	9¼ hours	2.70
Middle	do	4.45	Middle	do	2.45
Bottom	do	4.42	Bottom	do	1.55
Top	1 hour	——	Top	10¼ hours	2.50
Middle	do	4.5	Middle	do	2.45
Bottom	do	3.92	Bottom	do	1.40
Top	1¼ hours	——	Top	11¼ hours	2.60
Middle	do	4.25	Middle	do	2.40
Bottom	do	4.05	Bottom	do	1.40
Middle	1¾ hours	4.25	Top	13¼ hours	2.55
Bottom	do	3.50	Middle	do	2.40
Top	2¼ hours	5.20	Bottom	do	1.40
Middle	do	3.90	Top	15¼ hours	2.45
Bottom	do	——	Middle	do	2.30
Top	3¼ hours	3.75	Bottom	do	1.20
Middle	do	3.20			
Bottom	do	2.65			
Top	4¼ hours	3.55			
Middle	do	3.00			
Bottom	do	2.30			
Top	5¼ hours	3.00			
Middle	do	2.95			
Bottom	do	2.18			

With this milk and temperature it will be noted that there was but little change after the 10¼-hour period.

In the following tables are examples of milk creamed at higher temperatures; the results are given simply to show the effect of prolonged setting in such cases. They are not given to show the incompleteness of the creaming by this process, but simply to determine if any benefit can be derived by a prolonged setting when the temperature of the water in the tank is above 49° or 50° at the time of setting.

TABLE VI.

Can VIII. Milk set at 70° in water at 52°.				Can IX. Milk set at 86°. Water 49°. 3.80% Fat at setting.			
Section of Can.	Time from Setting.	Per Cent. Fat.		Section of Can.	Time from Setting	Per Cent. Fat.	
All sections at start.....		4.30		Top.....	20 minutes	3.95	
Top.....	1½ hours	4.40		Middle.....	"	3.80	
Middle.....	"	4.20		Bottom...	"	2.10	
Bottom.....	"	2.25		Top.....	1 hour	3.75	
Top.....	3½ hours	2.40		Middle.....	"	3.45	
Middle.....	"	2.20		Bottom...	"	——	
Bottom.....	"	.45		Top.....	2 hours	3.55	
Top.....	7½ hours	1.80		Middle.....	"	2.95	
Middle.....	"	1.35	Average	Bottom...	"	1.75	
Bottom.....	"	.30	1.15	Top.....	3½ hours	2.45	
Top.....	24 hours	1.65		Middle.....	"	1.80	
Middle.....	"	1.35		Bottom...	"	1.60	
Bottom.....	"	.20	Average .85	Top.....	5½ hours	1.80	
				Middle.....	"	1.30	
				Bottom...	"	.85	
				Top.....	9½ hours	1.25	Average
				Middle.....	"	1.00	.85
				Bottom...	"	.30	
				Top.....	24 hours	1.00	
				Middle.....	"	.80	
				Bottom...	"	.20	Average .66

In these tables the same points are to be noted as when the temperature of the water ranged from 40° to 47° F., except that the action is slower and the creaming far less perfect. At the end of 8¾ hours the average per cent of fat in the skim milk, due to the high temperature of creaming was 1.24 per cent., at the end of 25 hours it was 1.05 per cent.

The average of the eight trials when set at 47° showed that the creaming was practically completed before the end of the twelve hour period and that the skimming could then safely be done.

TABLE VII.

Can X. Milk set at 86° in water at 54°. 4.15% fat in original milk.				Can XI. Milk set at 84° in water at 54°. 4.25% fat in original milk.			
Section of can.	Time from setting.	Per cent. fat.	NOTES.	Section of can.	Time from setting.	Per cent fat.	
Top	½ hour	4.35		Top	1 hour	3.60	
Middle	do	4.20		Middle	do	3.45	
Bottom	do	3.55		Bottom	do	3.30	
Top	1 hour	3.50		Top	3 hours	3.50	
Middle	do	3.45		Middle	do	3.30	
Bottom	do	3.15		Bottom	do	2.15	
Top	2 hours	3.50		Top	5 hours	2.90	
Middle	do	3.15		Middle	do	2.85	
Bottom	do	1.60		Bottom	do	1.55	
Top	4 hours	——		Top	7 hours	2.35	Average
Middle	do	2.45		Middle	do	1.80	1.65
Bottom	do	1.40		Bottom	do	.80	
Top	6 hours	2.80		Top	27 hours	2.20	Average
Middle	do	2.20		Middle	do	1.50	1.35
Bottom	do	.60		Bottom	do	.35	
Top	8 hours	2.00					
Middle	do	1.80					
Bottom	do	.60					
Top	10 hours	1.80	Average				
Middle	do	1.60	1.30				
Bottom	do	.50					
Top	27 hours	1.55	Average				
Middle	do	1.45	1.13				
Bottom	do	.40					

In this setting no 9 or 10 hour period was taken so the results are not strictly comparable as to the closing period.

The average of 12 trials when set in water at temperatures varying from 50° to 60° F., showed that the creaming was practically completed within the same time. Although a slight gain resulted from a prolonged setting, in no case was this equal to the loss sustained for the want of a lower temperature at the beginning. A prolonged setting cannot make up for a low temperature at the time of setting.

EXPERIMENTS IN CHEESE MAKING.

HARRY SNYDER.

1. CHEESE MADE FROM NORMAL MILK RICH AND POOR IN FAT.

In cheese making, a great diversity of opinion exists as to losses of fat in working with different grades of milk. It has been claimed that when cheese is made from milk rich in fat that a large per cent of the total fat is lost in the whey, and that when the per cent of fat in the milk reaches a cer-

TABLE I.

Milk with percentages of fat ranging from 3.5 to 4.0 inclusive.

DATE.	Per cent fat in milk	Per cent fat in whey	Lbs. of Milk.	Lbs. of green cheese.
Jan. 20...	3.5	0.4	305	28.0
" 26...	3.6	0.3	"	30.
" 20...	3.7	0.4	"	27.
" 29...	3.7	0.4	"	29.
" 30...	3.7	0.3	"	29.
Feb. 3...	3.8	0.4	"	30.0
Jan. 12...	3.8	0.4	"	33.0
" 28...	3.8	0.5	"	29.0
" 23...	3.8	0.4	"	30.
" 30...	3.8	0.4	"	34.0
" 28...	3.9	0.3	"	30.
" 29...	3.9	0.3	"	29.0
" 27...	3.9	0.4	"	35.0
" 9...	3.9	0.4	"	32.0
Feb. 16...	4.0	0.4	"	——
Jan. 12...	4.0	0.4	"	34.0
" 22...	4.0	0.3	"	——
" 20...	4.0	0.4	300	30.0
" 22...	4.0	0.4	305	31.0
" 20...	4.0	0.4	300	30.0
" 12...	4.0	0.4	305	34.0
" 12...	4.0	0.4	"	34.0
" 11...	4.0	0.4	"	34.0
" 13...	4.0	0.4	"	34.
" 14...	4.0	0.3	"	33.0
" 13...	4.0	0.4	"	34.0
" 12...	4.0	0.4	"	32.0
" 18...	4.0	0.45	"	33.0
No. Trials 28.	3.85	0.38	304.7	31.46

TABLE II.

Milk with percentages of fat ranging from 4.1 to 4.4 inclusive.

DATE.	Per cent fat in milk	Per cent fat in whey	Lbs. of milk.	Lbs. of green cheese.
Jan. 19...	4.1	0.5	305	32.0
" 15...	4.1	0.3	"	31.0
Feb. 2...	4.2	0.3	"	31.0
Jan. 21...	4.2	0.4	"	32.
" 16...	4.2	0.4	"	31.0
" 14...	4.2	0.4	"	31.
" 18...	4.2	0.45	"	33.0
" 11...	4.2	0.4	"	34.0
" 14...	4.2	0.3	"	32.0
" 15...	4.2	0.3	"	32.0
" 9...	4.2	0.3	"	31.0
" 8...	4.2	0.4	"	34.0
" 15...	4.3	0.3	"	34.0
" 14...	4.3	0.3	"	34.0
" 14...	4.3	0.3	"	-35
" 15...	4.3	0.3	"	-32.0
" 9...	4.3	0.4	"	33.0
" 19...	4.3	0.4	"	32.0
" 15...	4.3	0.3	"	34.0
" 30...	4.3	0.4	"	-31
" 19...	4.3	0.4	"	32
Feb. 1...	4.4	0.3	"	35.0
Jan. 27...	4.4	0.4	"	
" 14...	4.4	0.3	"	35.0
" 23...	4.4	0.3	"	35.0
" 18...	4.4	0.4	"	34.0
" 18...	4.4	0.4	"	34.0
" 14...	4.4	0.3	"	35.0
" 16...	4.4	0.4	"	33.0
" 13...	4.4	0.4	"	33.0
" 11...	4.4	0.4	"	35.0
No. Trials 31.	4.29	0.36	305.0	32.8

tain point all the fat above that point is lost in the whey, and no more can be retained in the cheese. It is also claimed that only a small and definite per cent of fat can be utilized in cheese making. In order to obtain some knowledge upon this question, based upon actual experiments, the following work has been carried out. The cheese was made under the direction of Mr. Phillips, instructor in cheese making in the Dairy School of the University of Minnesota. In the following tables will be found grades of milk ranging from 3.5 to 5.4 per cent fat, classified in four groups together with the per cent of fat lost in whey in each case:

TABLE III.

Milk with percentages of fat ranging from 4.5 to 5.0.

DATE.	Per cent fat in milk	Per cent fat in whey	Lbs. of milk.	Lbs. of green cheese.
Jan. 13...	4.5	0.4	305	34.0
" 13...	4.5	0.4	"	34.0
" 9...	4.6	0.4	"	33.0
" 13...	4.6	0.4	"	36.0
" 11...	4.6	0.4	"	36.0
" 21...	4.6	0.4	300	32.0
" 21...	4.6	0.4	"	32.0
" 13...	4.6	0.4	305	36.0
" 11...	4.6	0.4	"	36.0
" 16...	4.6	0.4	"	33.0
" 12...	4.6	0.4	"	34.0
" 15...	4.7	0.3	"	34.0
" 25...	4.8	0.4	"	35.0
" 25...	4.8	0.4	"	——
No. Trials 14.	4.62	.39	304.3	34.2

TABLE IV.

Milk with percentages of fat ranging from 5.0 to 5.5.

DATE.	Per cent fat in milk	Per cent fat in whey	Lbs. of milk.	Lbs. of green cheese.
Jan. 23...	5.0	0.3	3 05	-36
" 23...	5.0	0.3	"	36.0
" 23...	5.0	0.3	"	-34
" 22...	5.4	0.4	"	-36
No. Trials 4.	5.10	0.32	305.0	35.5

GENERAL AVERAGES OF ALL THE GROUPS.

No. of Trials.	Milk with fat ranging from	Per cent. of fat in milk.	Per cent. of fat in whey.	Pounds of milk.	Pounds of green cheese.	Pounds of milk to make 1lb green cheese.
28	3.50-4.00	3.85	.38	304.7	31.46	9.68
31	4.10-4.40	4.29	.36	305.	32.80	9.30
14	4.50-4.90	4.62	.39	304.3	34.2	8.90
4	5.00- ——	5.05	.32	305	35.5	8.56

In these experiments, in which the cheese was made under the same conditions, the losses of fat in the whey are practically the same, whether the original milk was rich or poor in fat; and normal milks rich in fats were made into cheese without any greater percentage loss of fats in the whey, than poorer milk. It is also noted that where the milk was rich in fat it required a less number of pounds to make a pound of cheese.

INCORPORATION OF CREAM INTO CHEESE.

Inasmuch as the results of the previous experiment indicate that rich milk can be made into cheese with no greater loss of fat in the whey than poor milk, the question arises, can cream be incorporated into cheese?

This naturally resolves itself into two parts: first, can it be done; second, will it be a financial success. In this bulletin the first question alone will be discussed. In the following tables will be found in a condensed form the result of a number of experiments bearing on this question. The milk was divided into two portions, to one of which cream was added:

TABLE I.

DATE, January,	18	19	19	20	20	22	22
	Milk with cream added.	Milk with cream added.	Normal Milk.	Milk with cream added.	Normal Milk.	Milk with cream added.	Normal Milk.
Per cent of fat in milk	6.00	6.00	4.00	6.00	4.00	5.40	2.80
Pounds of milk in vat	300	300	300	300	300	300	300
Rennett test for ripeness	55	60	60	60	60	35	40
Temperature set	90	88	88	90	90	87	87
Amount of rennet used, ozs	1¼	1¼	¾	1½	¾	1.	¾
Minutes in curdling	12	25	25	14	14	8	13
Time required in raising to 120°, minutes	30	30	30	35	36	20	20
Hot iron test when dipped	⅛ in.	⅛ in.	⅛ in.	⅛ in.	⅛ in.	⅛ in.	⅛ in.
Per cent fat in whey	.40	.40	.40	.40	.40	.40	.40
Hot iron test when ground	½ in.	¾ in.	¾ in.	¾ in.	¾ in.	½ in.	½ in.
Weight of green cheese	38½	39½	32	36	30	36	28
Weight of milk per pound of cheese	7.79	5.79	9.39	8.33	10.00	8.33	10 71
Weight of whey	246	248	257	250	255	250	261

TABLE II.

Date	Kind of milk	Pounds of fat in Milk	Pounds of fat in Whey	Losses at Press. In liquids, lbs fat	Losses at Press. In solids, lbs. fat	Total lbs fat lost	Total lbs. fat recovered in cheese	No. lbs fat added in cream	No. lbs. fat added to cheese from cream	No. lbs. fat lost from cream
January 18...	creamed	18.00	.984	.072	.640	1.696	16.304	6	.....	.....
" 19...	creamed	18.00	.992	.060	.44	1.492	16.508	6	5.814	.186
" 19...	normal	12.00	1.028	.0779	.20	1.3059	10.694	0	.....	.....
" 20...	creamed	18.00	1.00	.0972	.656	1.753	16 247	6	5.73	.27
" 20...	normal	12.00	1.02	.0675	.40	1.48	10.52	0	.....	.....
" 22...	creamed	16.00	1.00	.0770	.24	1.317	14.883	7.8	7.655	.145
" 22...	normal	8.40	1.044	.0783	.05	1.172	7.228	0	.....	.....

EXPLANATION OF TABLES.—The column headed "total pounds of fat lost," includes the fat lost in the whey and at the press, both in liquids and solids; the total pounds of fat recovered is found by subtracting the total losses from the total pounds of fat in the milk. The number of pounds of fat added to the cheese from the cream is found by subtracting from the total fats in the creamed milks that of the normal milks of the same day, inasmuch as the milk was divided into two portions, to one of which cream was added and to the other it was not. The column headed "fat lost from cream," is the difference between the number of pounds of fat added to the milk as cream, and the number of pounds of fat added to the cheese from the cream.

From these tables it will be observed that by the addition of cream to milk so that the mixture contained about six per cent. fat no greater loss of fat occurred in the whey; a greater loss did result from the pressing of the creamed milks, this however, amounted to only a small per cent. of the fat added. Whether this loss will be more than balanced by the increase in the price received for this cheese yet remains to be seen.

In working with creamed milk the greatest losses are at the press, the solid material which resembles butter in appearance has a varied composition. In the column given as losses at the press, both the solids and the whey were analyzed separately, the solid matter ranges from 60 to 80 per cent. fat. The following is an example of this material, from a creamed milk, obtained at the press:

Water	13.53 per cent.
Fat	83.16 per cent.
Casein	1. per cent.
Ash and Salt	2.3 per cent.

To what extent cream can be incorporated into cheese without increasing the per cent. of loss in the whey depends largely upon the manipulation. The cheese made from creamed milk testing 7.6 per cent. fat, left in the whey .7 per cent. fat, indicating that the point in which cream can be added under the conditions in which these were made, without sustaining more than normal losses in the whey, lies somewheres between 6 and 7.6 per cent. of fat for the mixture. In each case it will be observed, where cream is added, that the weight of the green cheese obtained always exceeded that made from the same normal milk by more than the weight of the fat added to the cream.

In reviewing the tables in both of these articles on experiments in cheese making, it must be remembered that the per cent of fat left in the whey is, in a great measure, a test of the capabilities of the cheese maker and his apparatus. Daily work in the cheese factory of the dairy school shows this statement to be true among experienced makers. In working with rich milks every factoryman is urged to follow each step of his work with the test, to learn where the losses occur, then study what the causes are rather than attribute

any unusual losses to the high per cent of fat in the milk.

In these experiments an extended preliminary study was found necessary, to get all of the complicated factors under control, so that the conditions, processes and manipulations would be the same in all the different tests. All other known conditions therefore being the same, the variations in the results must be due to the variations in the per cent of fat in the milk, and the results recorded in the tables are therefore strictly comparable as to the loss of fat in the whey and at the press.

This report of the work is a summary of the results only. Complete analyses were made of the milk, whey, drippings and losses at the press both liquid and solid and determinations made of the protein compounds, sugar, ash, lactic acid, and fat in each by-product, but as these are necessarily technical in character a discussion of them is not given in this bulletin.

The whole question of the loss of fat in cheese making is one that requires careful consideration, for upon its right solution depends to a large extent the success of the factory. If it can not be demonstrated that, with normal milk, rich in fat, intelligent cheese makers can so incorporate the fat in the cheese as to leave as small a per cent of fat in the whey as with poorer milk, many patrons, owning herds of cows giving rich milk must advocate partial skimming at least. These experiments, however, seem to show that with rich milk the loss of fat in the whey is relatively less than where poor milk is used. The per cent of fat in the whey remains about constant, a little less than .4 per cent without regard to the quality of the original milk, hence the proportional loss in the whey is less with the richer milk both because there is more fat in the original milk and because there is a less proportional amount of whey. For example, in table I of the second article in the case of the 300 pounds of milk testing 2.8 per cent fat there was 261 pounds of whey, in the same weight of milk testing 5.4 per cent fat there was but 250 pounds of whey. The per cent of fat in the whey in each case was .4 per cent. The absolute loss of fat in the whey from the poor milk was 1.044 pounds while with the

rich milk it was but one pound. The absolute amount of fat in the poor milk was 8.4 pounds, while in the rich milk it was 16.2 pounds, hence the per cent of loss of the total fat of the whole milk was, in the whey of the poor milk 12.4 per cent, of the rich milk 6.25 per cent. This is one example taken from many. In the prosecution of this experiment ninety cheeses were made and the results in every case bear out the truth of the statement that the loss of fat in the whey is both relatively and absolutely larger with poor than with rich normal milk.

At the press, however, there are greater losses with the richer milk, occuring mainly in the solids of the drippings. The drippings were treated as follows: The total drippings from each cheese was caught in a stone jar and filtered through a weighed filter with slight pressure. The solids adhering to the sides of the jar were washed into the filter with portions of the filtrate. The solids and filtered whey were then weighed and analysed separately and gravimatrically. Attempts were made to dissolve this butter-like material with hot water and with chemicals but without success. In the case of the example last quoted the losses at the press from the cheese made from poor milk were .078 pounds in the liquids and .05 pounds in the solids, while with the 5.4 per cent milk, although the losses in the liquid were practically the same as with the poor milk, the loss in the solids was .24 pounds fat. Taking therefore the total fat lost in whey and drippings and dividing it by the total fat in the original milk we find that the per cent of total loss in the case of the poorer milk was 13 per cent while with the 5.4 per cent milk it was but 8.14 per cent.

The history of cheese making shows that the making of skim cheese however profitable temporarily to the individual maker is disastrous to the cheese trade of the state or section that makes the article. Any advice therefore that looks towards skimming at all should be listened to with caution. The results of these experiments tend strongly to show that, as far as the retention of the fat in the cheese is concerned there seems to be no legitimate excuse for the practice.

THE BABCOCK TEST AND CHURN.

CLINTON D. SMITH AND T. L. HÆCKER.

SUMMARY OF RESULTS.

This experiment was undertaken as a preliminary study of the question, how nearly the butter fat as indicated by the Babcock test in the whole milk of an individual cow can be accounted for in the butter, butter milk and skim milk. In the following table in which the results are tabulated, the first column contains the name of the cows under experiment; the second, the sum of the butter fat given by the cow in seven milkings as determined by the Babcock test; the third, the amount of butter fat in the butter churned from these seven milkings; the fourth, the amount of butter fat in the skim milk; fifth, the butter fat in the butter milk; sixth, the fat in the samples of the whole milk taken for analysis; seventh, the sum of the butter fat in the butter, skim milk, butter milk and samples; eighth the discrepancy between the indicated amount of butter fat in the whole milk and the amount accounted for in the products; it is marked plus when the amount found in the products exceeds the amount indicated in whole milk and minus when the latter is less than the former.

SUMMARY.

	POUNDS OF BUTTER-FAT IN						
	Whole milk.	Butter	Skim milk.	Butter milk.	Samples.	Totals.	Discrepancy.
Beckley.....	4.731	4.7000	.0621	.00865	.0567	4.8274	+.0964
Bess.....	3.1562	2.9729	.0702	.0119	.0343	3.0893	—.0669
Bess.....	3.1427	3.0518	.0708	.0107	.0264	3.1597	+.0170
Houston....	5.352	5.2635	.0719	.0064	.0568	5.3986	+.0466
Houston....	5.0517	4.7812	.0663	.0184	.0524	4.9183	—.1334
Maria.....	4.6517	4.6518	.0654	.0096	.0527	4.7795	+.1278
Olive.....	4.302	4.078	.0844	.0651	.0393	4.2668	—.0352
Olive.....	4.459	4.2903	.0783	.023	.042	4.4336	—.0254
Sully.....	5.502	5.218	.0981	.049	.043	5.4081	—.0939
Sw. Briar..	5.3619	5.337	.0739	.0189	.052	5.4818	+.1199
Sw. Briar..	5.5001	5.046	.0831	.0123	.0521	5.1935	—.3066
Topsy.....	3.0654	2.925	.0623	.0168	.0361	3.0402	—.0252
Topsy.....	3.1867	2.9959	.0662	.046	.0361	3.1482	—.0424

1. The bottles used in the analysis of the skim milk were graduated to one-tenth of one per cent only, but a variation of that amount in the reading would account for some of the discrepancies recorded above. As the milk was all separated by a hand centrifuge and repeated tests showed that no greater proportion of fat could be found in any of the skim milk, the column headed "butter fat in skimmilk" represents the total weight of skimmilk multiplied by the factor .001.

2. The scales on which the milk and butter were weighed are graduated to a tenth of a pound. Very much closer readings are desirable if not necessary in weighing the butter especially, as a variation of a tenth of a pound in the weight of that product would in many of the cases throw the discrepancy to the other side of the line.

3. The difficulty of taking a sample of butter for analysis that accurately represents the whole amount may account for still other of the discrepancies. Since the butter must be analyzed in any event whether the test or the churn is taken as the final arbiter in the comparison of different cows or different breeds, this factor is alike the misfortune of both methods.

4. If perceptible mechanical losses had occurred in the progress of these experiments, the sum of the fat found in the butter, skimmilk, buttermilk and samples would in every case have been less than the amount indicated in the whole milk, but the table shows that such is not the case.

5. Since the per cent of fat in the skimmilk remains about constant the total fat lost in the skimmilk is greater in the case of cows giving the larger quantity of milk. It is also relatively largest in the case of cows giving the milk poorest in fats.

6. The more exhaustive churnability of the cream as shown by the per cent of fat in the buttermilk was not in these experiments a characteristic of any one breed of cows; but here also the cow having a given amount of fat distributed through the least amount of milk, had of course the least amount of cream and buttermilk and therefore, the per cent of fat in the buttermilk remaining the same, the least absolute loss of fat therein.

7. To prevent waste of fat in the buttermilk, the cream from each cow had to be treated differently, in a manner peculiar to that cow, hence the churn is a test of the skill of the buttermaker as well as of the value of the cow.

8. In the analysis of acid skimmilk and buttermilk unless due allowance is made for the lactic acid and matters other than fat soluble in ether the usual gravimetric method is no more accurate than the Babcock test.

DETAILS OF THE EXPERIMENTS.

The cows selected for these tests were all fresh in milk. Beckley and Maria are grade Jerseys; Houston a cross-bred Guernsey-Jersey; Olive a grade Guernsey; Sweet Briar a registered Guernsey; Rose a grade Shorthorn; Bess a registered Holstein; Topsy a grade Holstein and Sully a native.

Each mess as soon as drawn from the cow was weighed and a sample weighing on the average 2 2-7 ounces taken for analysis. Seven of these samplss thus make one pound of milk and as they were thrown away their fat content is added to that of the butter, skimmilk and buttermilk as part of the fat in the whole milk not otherwise accounted for.

The milk was run through a hand centrifuge immediately after weighing, care being taken to wash all the cream from the bowl by liberal additions of skimmilk at the completion of the separation of each mess of each cow. The cream was then cooled and kept until seven milkings had accumulated when it was ripened and churned. Both the skimmilk and buttermilk were tested with the Babcock test; below is given in tabular form the detailed history of the experiment. The first column in the various tables shows the date of the milking, the second the weight of the milk, the third the per cent of fat in the milk as shown by the test, the fourth the product of the weight of milk multiplied by the per cent of fat or in other words the total fat in that milking, the fifth gives the weight of the skimmilk. As the experiment was performed in December the number in the first column designates the day of that month when the respective milkings were made.

Beckley.

Date	Whole milk, lbs.	Per cent fat	Total fat, lbs.	Skim milk, lbs.
26 p.m	12.5	6.	.75	9.4
27 a.m	13.	5.5	.715	10.8
27 p.m	11.	5.6	.616	8.3
28 a.m	11.5	5.9	.6785	8.4
28 p.m	11.	5.7	.627	7.
29 a.m	13.5	5.4	.729	10.
29 p.m	11.	5.6	.616	8.2
	83.5		4.731	62.1

Temperature of cream, 64°; time churning, 15 minutes; temperature when churned, 66°; when washed, 59°; when worked, 59°; buttermilk, 17.3 lbs.; per cent fat, .05; worked butter, 5.35 lbs; per cent fat, 87.85.

Butter fat in whole milk			4.731
"	"	butter	4.7000
"	"	skim milk	.0621
"	"	buttermilk	.0086
"	"	samples	.0567
Discrepancy			.0964
			4.8274 4.8274

Bess.

Date	Whole milk, lbs.	Per cent fat	Total fat, lbs.	Skim milk, lbs.
23 a.m	13	3.8	.494	9.4
23 p.m	13	3.7	.481	10.75
24 a.m	13.5	4.1	.5535	10.
24 p.m	13.	2.	.26	10.9
25 a.m	13	3.5	.455	9.6
25 p.m	12.75	3.6	.459	9.65
26 a.m	13.75	3.3	.4537	9.85
	92.		3.1562	70.15

Temperature of cream when churned, 64°; after churning 65°; when washed, 54°; when worked 56°; buttermilk 23.8 lbs.. per cent fat .05; worked butter 3.4 lbs., per cent fat 87.44.

Butter fat in whole milk			3.1562
"	"	skimmilk	.0702..
"	"	buttermilk	.0119..
"	"	samples	.0343..
"	"	butter	2.9729..
Discrepancy			.0669..
			3.1562 3.1562

Bess.

Date	Whole milk, lbs.	Per cent fat	Total fat, lbs.	Skim milk, lbs.
26 p.m	13	3.3	.429	9.7
27 a.m	14.75	3.1	.4572	9.65
27 p.m	15.	2.8	.42	11.4
28 a.m	15.	1.9	.285	10.6
28 p.m	12.25	3.2	.392	8.85
29 a.m	14.75	4.2	.6195	10.65
29 p.m	13.5	4.	.54	10.
	98.25		3.1427	70.85

Temperature of cream when churned, 62°; after churning 66°; when worked, 59°; time of churning 30 minutes; buttermilk 21.5 lbs.; per cent fat .05; butter 3.45 lbs.; per cent fat 88.46.

Butter fat in whole milk			3.1427
"	"	butter	3.0518
"	"	skimmilk	.0708
"	"	buttermilk	.0107
"	"	samples	.0264
Discrepancy			.017
			3.1597 3.1597

Houston

Date	Whole milk, lbs.	Per cent fat	Total fat, lbs.	Skim milk, lbs.
23 a.m	14	5.9	.826	10.6
23 p.m	12.5	6.4	.800	9.7
24 a.m	13.75	5.4	.7425	9.95
24 p.m	13.5	5.8	.783	11.1
25 a.m	14	5.8	.812	10.9
25 p.m	13	5.8	.754	9.9
26 a.m	13.5	4.7	.6345	9.8
	94.25		5.352	71.95

Temperature of cream when churned 64°; of butter when washed 55°; when worked 59°; buttermilk, 21.6 lbs.; per cent fat .03; butter 6.05; per cent fat 87.00.

Butter fat in whole milk			5.352
"	"	butter	5.2635
"	"	skimmilk	.0719
"	"	buttermilk	.0064
"	"	samples	.0568
Discrepancy			.0466
			5.3986 5.3986

Houston.

Date	Whole milk, lbs.	Per cent fat	Total fat, lbs.	Skim milk, lbs.
27 p.m	12.5	5.5	.6875	9.
28 a.m	14.75	6.	.885	10.95
28 p.m	12.25	5.8	.7105	8.15
29 a.m	14	5.3	.742	10.6
29 p.m	12	5.8	.696	8.7
30 a.m	13.75	4.6	.6325	9.75
30 p.m	12.25	5.7	.6982	9.15
	91.5		5.0517	66.3

Temperature of cream when churned, 63°; of butter when washed 55°; when worked 59°; time of churning 35 minutes; buttermilk 18.4 lbs.; per cent fat, .1; butter 5.6 lbs.; per cent fat 85.38.

Butter fat in whole milk		5.0517
" " butter	4.7812	
" " skimmilk	.0663	
" " buttermilk	.0184	
" " samples	.0524	
Discrepancy	.1334	
	5.0517	5.0517

Maria.

Date	Whole milk, lbs.	Per cent fat	Total fat, lbs.	Skim milk, lbs.
27 p.m	12.5	5.3	.6625	9.1
28 a.m	13.25	4.7	.6227	9.55
28 p.m	12.	5.4	.648	8.5
29 a.m	13.75	5.4	.7425	10.15
29 p.m	12.5	5.4	.675	9.1
30 a.m	13.5	4.9	.5615	10.
30 p.m	12.75	5.8	.7395	9.05
	90.25		4.6517	65.45

Temperature of cream when churned 64°; temperature of butter 66°; when washed 55°; when worked 58°; buttermilk 19.2 lbs.; .05% fat; time of churning 45 minutes; butter 5.3 lbs.; per cent fat, 87.77.

Butter fat in whole milk		4.6517
" " butter	4.6518	
" " skimmilk	.0654	
" " buttermilk	.0096	
" " samples	.0527	
Discrepancy	.1278	
	4.7795	4.7795

Olive.

Date	Whole milk, lbs.	Per cent fat	Total fat, lbs.	Skim milk, lbs.
23 a.m	16.	4.2	.672	11.5
23 p.m	14.	4.5	.63	10.5
24 a.m	17.1	3.5	.5985	12.8
24 p.m	15.5	4.1	.6355	14.3
25 a.m	16.	3.8	.608	11.9
25 p.m	15.75	4.4	.693	11.75
26 a.m	15.5	3.	.465	11.7
	109.85		4.302	84.45

Temperature of cream when churned, 62°; time churning 40 minutes; temperature of butter 64°; when washed 56°; when worked 58°; buttermilk 21.7 lbs.; per cent fat .3; butter 4.65 lbs.; per cent fat 87.70.

Butter fat in whole milk		4.302
" " butter	4.078	
" " skimmilk	.0844	
" " buttermilk	.0651	
" " samples	.0393	
Discrepancy	.0352	
	4.302	4.302

Olive.

Date	Whole milk, lbs.	Per cent fat	Total fat, lbs.	Skim milk, lbs.
26 p.m	14.75	4.2	.6195	10.95
27 a.m	16.	3.6	.576	12.
27 p.m	14.25	4.4	.627	9.85
28 a.m	15.5	3.8	.589	12.2
28 p.m	14.5	4.3	.6235	10.5
29 a.m	16.	4.4	.704	11.6
29 p.m	15.	4.8	.720	11.2
	106.		4.459	78.30

Temperature of cream 62°; time churning 30 minutes; temperature of butter, 65°; when washed 56°; when worked 60°; weight of worked butter, 4.85; buttermilk 23 lbs.; per cent of fat .1; per cent of fat in butter 88.46.

Butter fat in whole milk		4.459
" " butter	4.2903	
" " skimmilk	.0783	
" " buttermilk	.023	
" " samples	.0420	
Discrepancy	.0254	
	4.459	4.459

Sully.

Date	Whole milk, lbs.	Per cent fat	Total fat, lbs.	Skim milk, lbs,
23 a.m	20.5	4.8	.984	15.1
23 p.m	18.	4.	.72	12.6
24 a.m	20.	4.	.80	14.9
24 p.m	17.25	4.6	.7935	13.05
25 a.m	19.5	4.5	.8775	15.5
25 p.m	17.5	4.	.70	12.3
26 a.m	19.	3.3	.627	14.7
	131.75		5.502	98.15

Temperature of cream when churned, 62°; time of churning 45 minutes; temperature of butter 64°; when washed, 60°; when worked 62°; buttermilk with water added to secure separation from buttermilk 49 lbs.; per cent of fat in same, .1; worked butter, 5.85 lbs.; per cent fat, 89.20.

Butter fat in whole milk		5.502
" "	butter	5.218
" "	skimmilk	.0981
" "	buttermilk	.049
" "	samples	.043
	Discrepancy	.0939
		5.502 5.502

Sweet Briar.

Date	Whole milk, lbs.	Per cent fat	Total fat, lbs.	Skim milk. lbs.
23 a.m	16.25	5.	.8125	12.85
23 p.m	15.5	5.5	.8525	11.4
24 a.m	15.25	4.7	.7167	11.45
24 p.m	16.75	5.2	.871	13.15
25 a.m	17.25	4.6	.7935	12.65
25 p.m	16.25	5.1	.8287	10.65
26 a.m	15.25	4.1	.6252	10.95
	112.50		5.5001	83.1

Temperature of cream 64°; time of churning 33 minutes; temperature of butter 65°; when washed 55°; when worked, 58°; buttermilk 24.6 lbs.; per cent fat .05; butter 5.8 lbs.; per cent fat 87.

Butter fat in whole milk		5.5001
" "	butter	5.046
" "	skimmilk	.0831
" "	buttermilk	.0123
" "	samples	.0521
	Discrepancy	.3066
		5.5001 5.5001

Sweet Briar.

Date	Whole milk, lbs.	Per cent fat	Total fat, lbs.	Skim milk. lbs.
26 p.m	15.25	5.4	.8235	11.75
27 a.m	14.75	4.9	.7227	9.75
27 p.m	14.5	5.	.725	10.80
28 a.m	15.	5.9	.885	10.10
28 p.m	14.5	5.6	.812	10.50
29 a.m	14.5	4.6	.667	10.80
29 p.m	14.25	5.1	.7267	10.25
	102.75		5.3619	73.95

Temperature of cream, 63°; time churning 16 minutes; butter temperature 65°; when washed 62°; when worked 63°; buttermilk 18.9 lbs.; per cent fat .1; butter 6 lbs.; per cent fat 88.95.

Butter fat in whole milk		5.3619
" "	butter	5.337
" "	skimmilk	.0739
" "	buttermilk	.0189
" "	samples	.0520
	Discrepancy	.1199
		5.4818 5.4818

Topsy.

Date	Whole milk, lbs.	Per cent fat	Total fat, lbs.	Skim milk, lbs.
23 a.m.	13.	3.9	.507	9.6
23 p.m.	11.5	3.9	.4485	8.4
24 a.m.	13.5	3.7	.4995	10.1
24 p.m.	12.5	4.	.50	9.8
25 a.m.	13.25	4.	.53	9.95
25 p.m.	12.1	3.5	.4235	8.9
26 a.m.	13.25	2.1	.2782	9.45
	89.1		3.1867	66.2

Temperature of cream, 62°; time churning, 27 minutes; butter 66°, when washed, 59°, when worked, 63°; buttermilk, 23 lbs.; per cent fat, .2; butter, 3.45 lbs; per cent fat, 86.84.

Butter fat in whole milk		,3,1867
" "	butter	2.996
" "	skimmilk	.0662
" "	buttermilk,	.046
" "	samples	.0361
	Discrepancy	.0424
		3.1867 3.1867

Topsy.

Date	Whole milk, lbs.	Per cent fat	Total fat, lbs.	Skim milk. lbs.
26 p.m	13.25	3.8	.5035	10.25
27 a.m	12.75	3.7	.4717	9.35
27 p.m	11.5	2.9	3.335	8.2
28 a.m	12.5	3.1	.3875	8.7
28 p.m	12.	4.3	.516	9.
29 a.m	12.25	3.2	.392	8.75
29 p.m	11.25	4.1	.4612	8.05
	85.5		3.0654	62.3

Temperature of cream 64°; time churning 30 minutes; butter, temperature 67°; when washed 58°; when worked 62°; buttermilk 16.8 lbs.; per cent fat .1; butter 3.25 lbs.; per cent fat 90.

Butter fat in whole milk.....		3.0654
" " butter.....2.925		
" " skimmilk .. .0623		
" " buttermilk .0168		
" " samples .... .0361		
Discrepancy..... .0252		
	3.0654	3.0654

University of Minnesota.

Agricultural Experiment Station.

BULLETIN No. 20.

MAY, 1892.

FERTILIZERS.

IMPROVEMENT OF TIMOTHY. RAPE IN MINNESOTA.

PEAS AND OATS. FIELD PEAS.

☞ The Bulletins of this Station are mailed free to all residents of the State who make application for them.

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OATS SOWN WITH FIELD PEAS.

W. M. HAYS.

During the past two or three seasons numerous plats of field peas, and oats with peas, have been grown on the Experiment Farm to study how best to grow these crops for feed. All the plats were grown on land in good heart. It is a mixture of sand and clay, has good power to hold moisture, while a stratum of sand and gravel at a depth of several feet provides perfect underdrainage. In 1890 experiments were made on fall plowed stubble land and in 1891 on fall plowed timothy sod.

In 1890 nine one-third acre plots 33 rods long were planted to oats, peas and the two mixed. The facts are tabulated below. The weather was favorable to the stooling of the oats and where even only a half bushel of oats was used with peas the crop was mainly oats. White Canada field peas used alone produced a good crop. Oats alone yielded a medium crop of poor quality, weighing only 25 pounds per bushel. Separating the oats and peas in the crop, the yield per acre of each is presented in the table. Estimating peas at 80 cents and oats at 25 cents per bushel, the relative values of the several crops are also shown. The straw of peas is worth more than the oat straw but as the values of these rough feeds are but poorly determined no estimate is attempted.

PEAS AND OATS IN 1890.

Plot.	Manner of Seeding.	Qts. per A.		Straw yield, lbs.	Yield per Acre.		Value per Acre.		
		Peas.	Oats.		Peas, bu.	Oats, bu.	Peas.	Oats.	Total.
11	Drill 8 in.	96	.....	2688	25½	....	$20.40	.....	$20.40
12	Drill, 8 in.	80	32	3215	5	8	4.00	$2.00	6.00
13	Plowed under	96	.....	2236	23½	.....	18.80	.....	18.80
14	Drill, 8 in.	60	36	3240	3½	37	2.80	9.20	12.00
15	Plowed under	93	.....	2619	19	.....	15.20	.....	15.20
16	Drill, 8 in.	54	18	2420	2⅓	23	1.90	5.70	7.60
17	" 8 "	96	16	1749	1⅔	17	1.30	4.30	5.60
18	" 8 "	80	32	2364	2½	29⅓	2.00	7.30	9.30
19	" 8 "	.....	80	3495	.....	35½	.....	8.90	8.90
Av.—	Oats alone	.....	80	3500	.....	35½	.....	.....	8.90
"	Peas alone	96	.....	2500	23⅔	.....	.....	.....	18.90
"	Oats and peas	.....	.....	2500	.....	.....	.....	.....	8.10

PEAS AND OATS IN 1891.

Plot.	Manner of seeding.	Qts. per A.		Straw yield, lbs.	Yield per Acre.		Value per Acre.		
		Peas.	Oats.		Peas, bu.	Oats, bu.	Peas.	Oats.	Total.
1	Drilled.		100	3593		55		$13.70	$13.70
2	"	120		2653	15⅔		$12.53		12.53
3	"	85	22	3233	2	38	1.60	9.50	11.10
4	"	105	22	2293	2⅓	38	1.90	9.50	11.40
5	"	102	31	2980	4	36	3.20	9.00	12.20
6	"	120		2800	20		16.00		16.00
7	"		107	3193		55		13.70	13.70
9	"	95	12	3328	1	32	.80	8.00	8.80
10	"	80	40	3587	1½	25	1.20	6.20	7.40
11	"	96	24	3413	2	30	1.60	7.50	9.10
12	"	92	28	2966	4½	27	3.60	6.70	10.30
13	"		87	3733		54		13.50	13.50
14	"	107		3547	14		11.20		11.20
Av.—	Oats alone		3 bu.	3500		54⅔			13.90
"	Peas alone	1 9-10 bu.		3000	16½				13.20
"	Oats and peas	1½bu	½ bu.	3000					10.00

PRACTICAL SUGGESTIONS.

The results suggest a few practical considerations.

(1.) With the conditions suited to the stooling of oats even a small proportion of oat seeds will cause the peas to be a light crop when sown by mixing in the seed drill; this occurs on rich moist soils nearly every year, rarely on sandy, drouthy soils.

(2.) Peas made the best crop in 1890 when plowed under and sown alone. Farmers on sandy lands claim the best results from plowing the peas under to a depth of 4 or 5 inches and then sowing the oats with seeder or drill. The further trials of pea and oat succotash could include a test of this plan.

(3.) Though no figures have been recorded several comparisons have shown that peas do not do nearly as well on our timothy sods as when following a grain crop.

(4.) Oats and peas together or peas alone can be successfully threshed with ordinary threshing machines, and the whole peas can easily be separated from oats and split peas by screening and by allowing the whole peas to roll down an inclined plane.

(5.) Oats and peas sown together have not proven as profitable as when grown separately, but where the oats will serve to hold the peas erect good combined crops are produced. Peas alone are such a good crop on soils suited to their growth that our most erect sorts should be selected and improved. This done and harvesting machinery perfected and pea crops will be as popular to raise for sale and for feed as are oats. They have an especial value in rotations with our grain crops.

(6.) The greatest needs in raising peas are a knowledge of what varieties to sow on each kind of soil, and a harvesting machine that will lay the vines in "rolled up" bunches much as a man does in mowing them with a scythe.

(7.) Mr. Andrew Boss, foreman, who attended to most of the details of crop trials, tried every way we could invent to harvest peas. The best way tried was to cut with a two horse mowing machine having two men with forks following on stations to roll the swath out of the way of the returning team. The mowing can not be successfully done when the vines are wet.

(8.) Peas for green feed, for hay, for hay and grain, for grain to sell and for silage, also to get land ready for other crops are bound to be much used, especially on our sandy lands.

FIELD PEAS IN MINNESOTA.

During the past three years numerous experiments have been in progress to determine the best methods of growing field peas, the best varieties for Minnesota and their general value as a field crop to be grown as a money crop or for feed. Progress along these lines is reported below.

BEST VARIETIES OF FIELD PEAS.

There are four general classes of varieties of field peas which are well adapted to Minnesota conditions. They are the Canada Blue Field Peas and the Canada White Field Peas, both of which have smooth, hard seeds; and Black Eye Marrowfat and White Marrowfat peas, both of which are large, wrinkled and not so hard as the Blue and White Canada field peas. Every seedsman has so called varieties of these classes of peas which he advertises. Doubtless many of them are nearly identical. There seems to be two subclasses of the White Canada pea, some calling one Prince Albert and the other Common White Canada Field Pea. The Prince Albert class has larger, finer seeds but has yielded no more per acre than the other class with us. Most of the notes of time of ripening, habit of vines, and part of the notes of yield of grain and straw for 1889 and 1890 were destroyed by fire. The table below gives the yields of the varieties of the four classes of peas for 1891, and 1890 and a few of 1889. There is no general marked difference in the yields of these four classes of field peas. In 1891 the 24 varieties of seed we had culled out of the greater number sown before yielded an average of 28 bushels per acre on "old land," that had been cultivated for twenty or more years with, so far as known, no application of manure. In 1890 these same varieties averaged 18½ bushels per acre. The average yields of the four classes for the years 1890 and 1891 are shown below.

TABLE NO. 1.

VARIETY TEST OF FIELD PEAS.

Plot No.	Varieties Sown May 5th, 1891.	Bush. seed sown per acre.	Bushels grain per acre, 1891.	Pounds straw per acre, 1891.	Bushels grain per acre, 1890.	Bushels grain per acre, 1889.	Original Source of Seed.	Plants stand erect.
2	Common Blue Field Pea	3½	29	3209	28	40	Experiment Farm	Fairly
3	Blue Russian Pea	3¼	29	4791	51	32	Experiment Farm	Down
4	Blue Canada Pea	3	34½	3860	19		P. Henderson	Well
5	Blue Canada Pea	3	29	3140	20		Experiment Farm	Well
6	Blue Imperial Pea	3	28⅔	3349	16⅓		B'dgr States. farm	Fairly
7	Choice Blue Pea	3	28½	3570	18		Ferry	Fairly
8	Common White Field Pea	3	24⅔	2000	17½		Ferry	Fairly
9	White Field Pea	3	24½	4814	18		Ferry	Well
10	White Canada Pea	3	24	3093	15		Experiment Farm	Down
11	White Prince Albert Pea	3	28	2977	22		N. B. & Goodwin	Down
12	No. 1 White Field Pea	3	24	2512	17		Ferry	Down
13	Common White Pea	3	28⅓	3651	23¾	40	Gregory	Down
14	White Field Pea	3	23⅔	3116	17½		Ferry	Down
15	White Canada Field Pea	3	25½	3116	15		Experiment Farm	Down
16	White Canada Field Pea	3	26⅔	2581	.....		Experiment Farm	Down
17	White Marrowfat Pea	3	31⅔	3442	21		N. B. & Goodwin	Fairly
18	Tall Marrowfat Pea	3	31	3244	.....		Experiment Farm	Down
19	Black Eye Marrowfat Pea	3	32½	4326	17½		Experiment Farm	Down
20	Black Eye Marrowfat Pea	2½	33⅓	2651	18⅔		B'dgr States. farm	Fairly
21	Black Eye Marrowfat Pea	2½	30⅓	1209	20½		Maule	Fairly
22	White Marrowfat Pea	2½	34	3768	22½		B'dgr States. farm	Fairly
23	Veitches Perfection Pea	2½	24½	2954	9¾		Experiment Farm	Fairly
24	Scotchman Pea	2½	21	2930	16		N. B. & Goodwin	Well
25	Latest of all Peas	2½	23⅓	4186	.....		Sutton & Son, Eng	Well

TABLE NO. 2.

AVERAGE YIELDS OF FOUR CLASSES OF PEAS.

Varieties.	Bus. per Acre, 1890.	Bus. per Acre, 1891.
Blue Canada Field Peas	18	30
White Canada Field Peas	18¼	26
White Marrowfat	22	32
Black Eye Marrowfat	19	32

The yields did not vary so widely as was expected. In 1890 the Blue Prussian which has been a heavy yielder of straw went down very badly and did not yield many peas, and we could not save all that were matured as the vines laid so low. I was agreeably surprised to find the Marrowfat varieties such good yielders of grain. I will not undertake at this time to advise as to varieties. Some help can be obtained from the tables and with catalogues of a few reliable

seedsmen the purchaser will stand a good chance of procuring a good stock of seed. Many varieties of common garden peas have been tried but all give too small a yield to compare favorably with the four classes above named for field purposes.

From a study of the individual plants grown alone and in fields I believe that no easier line of improving varieties exists in any class of field crops than in peas. And it would be quite worth the while of Experiment Stations, of seedsmen and of amateurs to try to improve field peas by selecting and by cross fertilizing. The individual plant is easily studied and the flower can be artificially cross fertilized without great trouble. I have found the two great sources of loss in the crop of peas to arise from a lack of ability to stand erect on the part of the stems, thus causing the whole plant to become infested with fungus parasites ("moulds") and the seed to be thus lessened in quantity. And in the second place the legumes burst so quickly in case of most varieties, when the crop is drying that a very large per centage of the seeds shell out before they can be secured on the wagon. Those who undertake the improvement of these peas should look to getting stockier plants and pods that are tough. Some of the seed now on hand will make excellent foundation stock for careful work in improvement.

METHODS OF SEEDING FIELD PEAS.

The tabular statement below shows the results of seeding Canada blue field peas in several different ways. Very wet weather, while curing the vines, caused delay and consequent loss of peas as the alternate wetting and drying of the pods caused them to open and the peas to be lost. The largest two yields of grain were produced on plot six, drilled eight inches apart and seeded at the rate of three bushels per acre; and plot four, drilled twenty-four inches apart and cultivated, one bushel and three quarts per acre. The smallest yields of grain were on plot one, drilled eight inches apart, two and one-half bushels of seed per acre, and plot seven, sowed broadcast at the rate of 3½ bushels seed per acre. The largest two yields of straw were on plot three, one bushel seed per acre in drills 16 inches apart, cultivated between the rows,

and plot two, 1¼ bushel seed per acre, drills 16 inches apart and cultivated; while the smallest yields of straw were on plot four on which one bushel three quarts of seed per acre was sown in drills 24 inches apart and cultivated, and on plot five on which 1¼ bushels seed per acre was placed in drills 16 inches apart and cultivated. This land was clover and grass sod, spring plowed, and was fairly fertile. This is certainly a good example showing that repeated trials with field plots are necessary to give reliable figures. These plots were 33 rods long and no difference in the land can be observed upon inspection.

Plot.	Distance Apart of Drills.	Amount Seed per Acre.	Yield Peas. per Acre.	Yield Straw per Acre, lbs.
1	8 inches	2¼ bushels	6 bushels...	1945
2	16 in., cultivated	1¼ bushels	9.3 " ...	2238
3	16 in., cultivated	1 bushel	7.1 " ...	2604
4	24 in., cultivated	1 bushel and 3 qrts..	9.8 " ...	1452
5	16 in., cultivated	1 bushel and 8 qrts..	7.8 " ...	1542
6	8 inches	3 bushels	10.1 " ...	1671
7	*Sowed broadcast	3½ bushels	6.3 " ...	2112
8	*Sowed broadcast	2½ bushels	8.2 " ...	2097
9	*Sowed broadcast	1 bushel and 3 qrts..	7.2 " ...	1976

*Covered with Disk Harrow.

The yield on this sod land was not more than half as good as on land very similar which had borne two crops of corn since the clover and timothy sods were turned under. In this case cultivation did not pay, but more experiments are needed in this line also.

The above results were obtained with a white variety of peas. Our practice has been to plant with a common shoe drill about three bushels of peas per acre, and letting them be covered 2½ to 3 inches deep. They will stand being planted twice as deep but our general practice on many plots and with many varieties has been so uniformly successful that we can commend it.

RAPE IN MINNESOTA.

Rape (*Brassica napus*) is grown in England for fattening sheep and also to some extent in Canada. There it is usually sown in June or July and used for fall pasture for fattening lambs, cleaning the ground of weeds and enriching it with the manure dropped. As some grain is given in addition, the land is considerably enriched.

When growing, rape appears much like rutabaga turnips, though it has not a thick root. It grows taller than the turnip forming a stem a foot or more high which bears many succulent leaves. On very clean land it may be sown broadcast as Dutch turnips, but it will serve a double purpose on weedy land if sown in drills and cultivated a few times, as besides furnishing a crop of feed, the land is cleaned of weeds and nicely prepared for wheat or other grain. In Canada the farmers often sow rape after removing a crop of rye or after using it for pasture, or cutting it a little early for hay. The same plan might be followed here where the rape is wanted for very late sheep pasturage. It may also be grown on land not plowed until time to seed the rape, thus taking the place of summer fallow. We grew some rape last season on land on which we had mowed a crop of peas and oats, mixed, for hogs. There seems no reason to doubt that rape will do well on any of our lands suited to corn or potatoes. As it is used elsewhere only for fall feed we have no experience with it or knowledge of it except when sown about the first of July. Some grown on the Experiment farm last season did well and in September Prof. Shaw, of Ontario Agricultural College, said it was a good average crop as compared with rape grown in Ontario. Prof. Shaw has done considerable experimenting with rape and as he knows the practical methods used in its growth in Canada we have followed his advice largely in starting to grow it here. He says it does best to sow it late in June or early in

July so that it may develop in the cooler weather in the fall, but not so late that it will be too succulent or watery when wanted to be fed off. The last week in June would seem to be the best time for the vicinity of St. Paul.

Following Prof. Shaw's advice we sowed in drills two feet apart, on land already well cleaned, and cultivated a few times to keep down weeds. One pound per acre of Dwarf Essex Rape seed was used. If sown broad cast three pounds per acre should be used. We prepared the land nicely but did not ridge up as is the practice in the old country. Ridging up for planting seeds in this country, subject to periods of drouth, is thought to be an injury. Our farmers will look upon cultivating rape as tedious, especially in weedy land where the hand hoe must be used to clean out the rows, but our state is becoming so befouled with weeds that we must learn to fight them, and by more profitable means than the bare summer fallow. When the rape is a foot or more high sheep may be turned into it and allowed to pasture it until very late as it withstands frosts until the freezing is very hard. Animals eating frozen rape are subject to digestive troubles and it must be cautiously done, if done at all. Rape makes good pasturage for cattle and hogs also are said to be fond of it. For dairy cattle it is hardly allowable as it taints the milk.

About the only caution needed in turning sheep on rape is that they be well fed on other feeds for a few days or allowed only a short time in the rape at once. When turned in hungry they are liable to eat so much that bloating is caused. Ewes which are to be bred are liable to become too fat if pastured on rape for one or two months in the fall.

RESULTS OF FEEDING RAPE TO SHEEP.

Early in October, after a week's preliminary feeding, eight sheep were divided into two groups, each containing two aged ewes, one yearling and one lamb, all Shropshires. Group 2 was placed in the rape day times and housed without other feed at night. Group 1 was given all the timothy hay, containing a little clover, they would eat, and were allowed a small yard to exercise in. Group 2 ate one-fifth acre of rape in thirty-two days. During the same period Group

1 ate 387 pounds of hay. Group 2 gained ¼ pound each daily and Group 1 gained ⅛ pound each daily. The following table shows the results:

Group.	Number of Sheep.	Pounds of hay eaten.	Amount of rape eaten.	Average weight of sheep..	Total gain in 32 days.	Average daily gain per head.
1	4	387		113.5	16	⅛
2	4		1-5 acre.	120.2	34	¼

In terms of an acre, one acre of rape was eaten while the sheep fed hay ate nineteen-twentieths of a ton. Counting the increase of live weight at 4 cents per pound (the current value of sheep for feeders) and the hay at six dollars per ton (an average on Minnesota farms) and we have the acre of rape equal to $5.70 worth of hay and $3.20 worth of mutton more than was produced by hay on Group 1. We thus have one acre of this rape worth, for very late pasturage for stock, sheep the sum of $8.90. This crop seems very promising as being adapted to add one more small diversity to Minnesota's Agriculture. With the increase of sheep raising, we have hopes that rape may prove very useful.

IMPROVEMENT OF TIMOTHY.

WILLET M. HAYS.

Efforts to improve our common field crops have not been pushed with as much vigor as the cost such improvements would incur in proportion to the great interests these crops represent would justify. Believing that experiments looking toward the improvement of those pasture and hay plants which are most extensively used would best repay the expenditure, timothy and red clover were selected and a start was made two years ago. Very little progress has been made in case of clover, but with timothy the foundation seems to have been laid.

In 1889 seeds of selected stocks or plants of timothy were gathered, and in 1890 a few hundred of these seeds were planted in good soil. Each seed was given more than one square foot of ground in which the resulting plant could spread. In selecting these seeds the effort was to secure a foundation stock of plants with some distinguishing mark, that any improvements which might be made would be on plants easily recognized as different from ordinary timothy, of which there is only one species or variety in common use in this country. It had been observed that the anthers of timothy at the time it is in the "blue bloom" vary in color from light straw color to dark blue. Plants representing the two extremes were marked when in bloom and when ripe the seeds were saved, the intention being to fix the colors as the distinguishing marks of two varieties.

The rich soil and ample room caused the plants to make unusually strong growth, and a number of them retained the colors sought to be perpetuated. But this rich feeding forced the plants into a much stronger growth than occurs when crowded together in pasture or meadow. When headed out the second year, the plants then being 15 months old,

each one had spread by stooling to ten inches or less in diameter, some much more than others. Some had longer heads, were taller, had longer radicle leaves and were apparently much stronger and more desirable plants than others. Eight of the 324 plants developed some of the spikelets into marked branches, as shown in the photographic plate on the opposite page. As nearly all the spikes, 20 to 50, on each plant showing this variation had the branches, it is safe to assume that this feature can be made a fixed character by selection in a few to several years. These branches are useful mainly as a mark to go along with other intrinsic qualities, but they have a direct use in making the yield of seed greater. It would seem easy to continue or fix this characteristic by selection, and at the same time select to get plants better adapted to the various purposes for which timothy is grown. I was able from this first generation of plants to choose those having large size, long stem and radicle leaves, great spreading or stooling habit, tall, strong, and as shown by the natural sized photographs, long, heavy bearing "heads" or spikes.

In climates subject to drouth, as is this, all grasses that do not send out root-stocks underground, but spread only by stooling, do not make a continuous sod but grow in bunches. The hay and pasture is less in quantity and coarser in quality than if the blades and culms grew close and fine. Prof. Waldron, of North Dakota, says he has seen timothy plants which had the bulb so modified that but little further change would produce underground root-stalks. Such plants would be even better foundation stock to start with than that first used in the work above mentioned. This report of progress is here given to illustrate the possibilities in this line of field crop experiments rather than to report finished results. Heads of barbed timothy are observed at very rare intervals in fields. The variation in timothy plants is even more than is observed between the scrubbiest stalk of corn and the stalk which grows tall and produces one or more large ears. The same may be said of other grasses and clovers.

FERTILIZERS IN MINNESOTA.

W. M. HAYS AND D. N. HARPER.

During some recent years wheat did not prove as successful in many parts of Minnesota as when the land was first occupied. Newly broken land, as well as that which had borne several crops, would not yield as much wheat as was grown by the pioneers. Many theories for this decline were advanced. Many who had formerly lived in New England regarded it as soil exhaustion, and that we are causing ruin by shipping out of the state and removing from our lands the bulk of its fertility. Experiments to study this point were started in 1888 at this station. In that year nitrate of soda, sulphate of potash and superphosphate of lime, alone and in mixtures, also common salt and lime, were applied by Dr. Porter to plots on a centrally located field on the Experiment Farm. Each fertilizer and mixture was applied to wheat, oats, barley, flax, potatoes and beets. The soil was of more than average native fertility, but had been cropped, mainly to wheat, for thirty years, and but little manure had ever been applied to it. The soil is a black loam, while the subsoil is made up of clay and considerable sand, and at a depth of several feet is underlaid with gravel. The results of this trial were recorded in Supplement I to the Fifth Biennial Report of the University of Minnesota, p. 137 to 160, inc. As that report is out of print, the following summary is here quoted, giving some of the results, simply to show the general rich character of this "upland" soil:

"Nitrogen, in the form of nitrate of soda, had the effect of increasing the growth of the young plants of wheat, oats and barley so that they were larger and stronger, and better withstood the attacks of chinch bugs, which were very numerous. The effect on weight of grain could not be determined, as the chinch bugs prevented their ripening. Nitrate of soda

increased the weight of oat straw over one-half ton per acre, and of grain three bushels per acre. Probably this increase in grain was due to the ranker growth of straw where nitrogen was scattered—being less favorable to the chinch bugs, which slightly injured the entire crop. Three hundred pounds per acre of nitrate of soda more than doubled the weight of flax straw, but did not increase the yield of flax seed per acre. Seven or eight bushels per acre less of potatoes were grown on the plots treated with 300 pounds nitrate of soda than on unmanured plots. Nitrogen increased the yield of mangels two and one-half tons per acre. Clover produced many flowers and seeds (the same year as sown) on plots not fertilized with nitrogen, but on all those upon which nitrate of soda was placed very few flowers were formed, though the leaves grew nearly or quite as strong. It has long been known that nitrogen increases the growth of straw more than grain. But in this case the clover was apparently kept from producing seeds the first year, on several plots by the application of nitrogen.

"Sulphate of potash and superphosphate of lime, applied together, showed an increase of one-fourth ton per acre of oat straw and flax straw, but no more grain. These two fertilizers caused no increase of potatoes or beets.

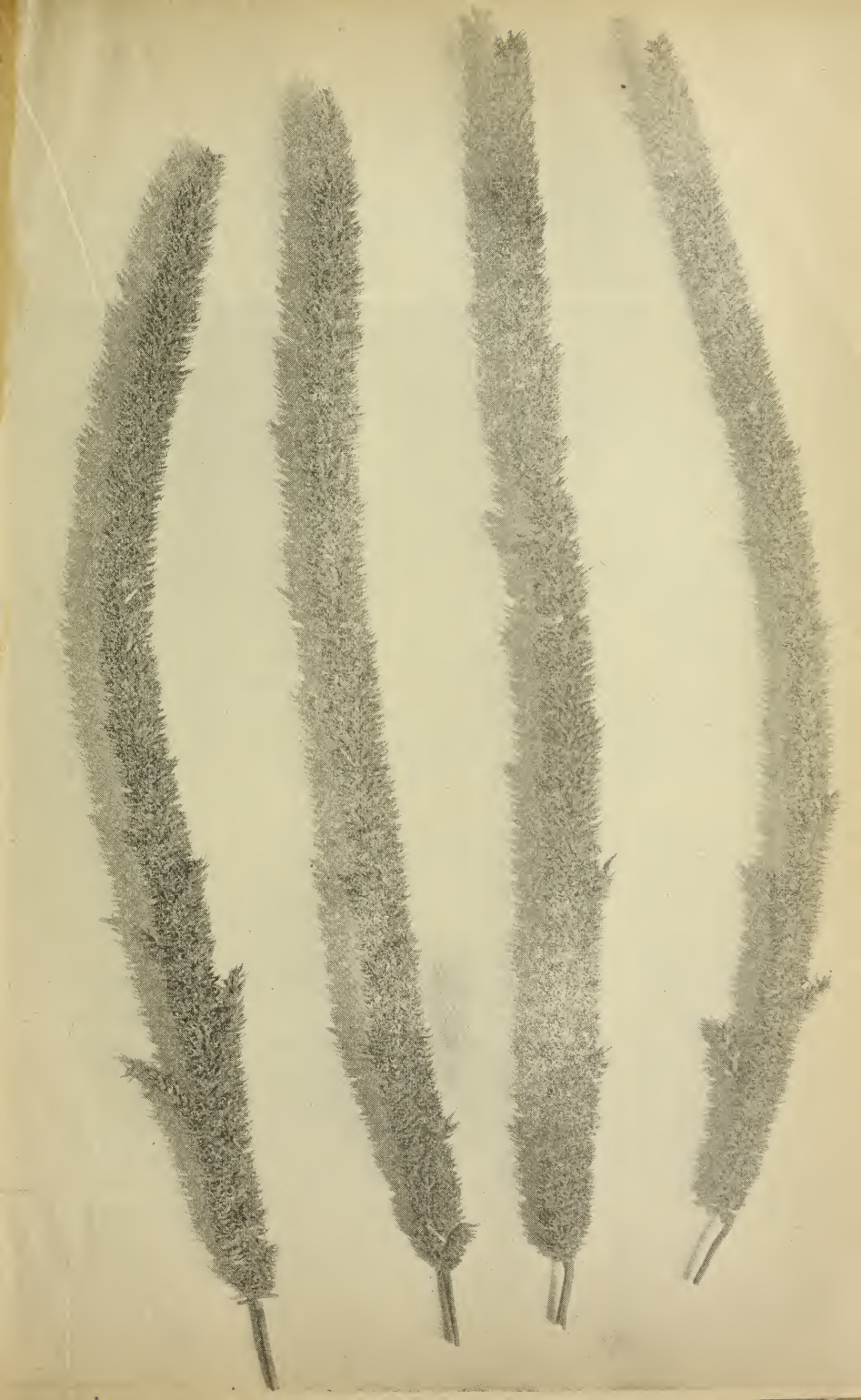
"Lime caused no increase of oat or flax straw or of oats, but in this single trial increased the yield of flax seed one bushel per acre. Lime lessened the quantity of potatoes and beets.

"Fifty bushels of salt showed an increase of five bushels per acre of oats, and 200 pounds of oat straw; of flax seed one and one-half bushels, and of flax straw 500 pounds, and of beets one and one-half tons per acre. No increase of potatoes was shown from the application of salt.

"None of these fertilizers caused enough increase to pay their cost."

TRIALS IN OTHER COUNTIES.

In 1890, in response to requests from various parts of the state, experiments were begun to study the needs of the soil of the entire state and to learn, if possible, whether there is a general lack of one or more of the elements of fer-



tility. Along with practical trials of the kinds of fertilizers most often found beneficial in older countries, samples of the soil were taken for chemical analysis. It was not believed that the time had come in Minnesota for the general use of commercial fertilizers, but that the time had come when it was wise to know from actual experiments, regarding our soils.

Commercial fertilizers were purchased and experiments were instituted on the so-called "worn wheat lands" in three widely separated parts of the State, viz: at Warren, Marshall County, in the northern part of the Red River Valley; at Windom, Cottonwood County, in Southwestern Minnesota, and at Taopi, Mower County, in the southeastern part of the State. At Warren, March & Spalding gave land on their large farm, also all needed labor, and in every way possible assisted in the work. To Sen. S. A. March, of Minneapolis, manager, our hearty thanks are due. At Windom the plots were on Mr. S. Huntington's farm. Here also careful assistance was rendered by Mr. S. H. Rydeen, foreman. At Taopi land was secured on the Chamberlain Farm. Our thanks are due Mr. H. H. Crossett, manager, for his careful assistance.

At Warren there were twenty plots of wheat and eighteen plots of oats; at Windom twenty-one plots barley and eighteen plots of flax. and at Taopi twenty plots of barley and twenty of wheat.

The plan upon which these experiments were made was as follows: Upon equal sized, contiguous and very long-shaped plots definite quantities of fertilizers were spread. Each fertilizer contained but one fertilizing ingredient, or two or more ingredients by making mixtures in definite proportions. To determine the absolute worth of each fertilizing ingredient or mixed fertilizer there was left unfertilized a sufficient number of plots for comparison. The statement of results further on gives the plan in detail as it was carried out at each place.

The fertilizers used and their analyses are as follows:

MURIATE OF POTASH—82.48 per cent, pure.

Equivalent to potash, K_2O	52.12	"

GOLDEN HARVEST PHOSPHATE—Phosphoric

acid, total	14.62	per cent
Phosphoric acid, soluble	2.96	"
" " insoluble	3.85	"
" " reverted	7.81	"
Nitrogen	1.74	"

LAND PLASTER—91.74 per cent, pure.

Lime, Ca O	33.33	per cent
Sulphuric acid, SO_3	39.38	"

SOUTH CAROLINA ROCK.—

Phosphoric acid, total	15.76	per cent
" " soluble	8.15	"
" " insoluble	2.10	"
" " reverted	5.51	"

NITRATE OF SODA.—90.17 per cent, pure.

Nitric anhydride, N_2O_5	53.22	per cent
[Nitrogen]	[13.8]	"

The prices per ton charged for the several fertilizers used and where obtained, are shown in the following table:

Nitrate of Soda, $48.00 per ton. Bowker Fertilizer Co., Boston, Mass.
Muriate of Potash, 40.00 per ton. " " " " "
Superphosphate,... 20.00 per ton. " " " " "
Land Plaster $1 to 2.00 per ton. Land Plaster Co., Ft. Dodge, Iowa.
Tankage, $13.00 per ton. St. Paul, Minn.

Salt, $5.00 or less per ton.
Lime, $3.00 to $10.00 per ton, owing to locality.

In the destruction by fire of our station building October 5, 1890, all records of results at Taopi were lost, while those at Warren and Windom have been only partially obtained from records left with the farm owners; many notes regarding growth, etc., being entirely lost. The accompanying tables, I., II., III., IV., give the amounts of fertilizers used and the results in yields in tabular form.

TABLE I.

WHEAT AT WARREN.

No.	Kind of Fertilizer.	Pounds per Acre.	WHEAT. Pounds on Plot.	WHEAT. Bush per Acre. bu lb	Average. Pounds on Plot.	Average. Bush. per Acre.
1	Salt	135	189	12–36	181¼	12– 6
2	Salt	270	173½	11–34		
3	Lime	160	166	11– 4	166½	11– 6
4	Lime	80	167	11– 8		
5	No Fertilizer	.....	171	11–24	171	11–24
6	Nitrate of Soda	140	147	9–48	161	10–44
7	Nitrate of Soda	280	175	11–40		
8	Complete Fertilizer: Nitrate	100	.....	.....	.....	.....
	Complete Fertilizer: Muriate	100	217½	14–30	217½	14–30
	Complete Fertilizer: Phosphate	200	.....	.....	.....	.....
9	Complete Fertilizer: Nitrate	200	.....	.....	.....	.....
	Complete Fertilizer: Muriate	200	Lost.	.....	.....	.....
	Complete Fertilizer: Phosphate	400	.....	.....	.....	.....
10	Plaster	160	199	13–16	197¾	13–71
11	Plaster	350	196½	13– 6		
12	No Fertilizer	.....	184	12–16	184	12–16
13	Muriate of Potash	280	183	12–12	183½	12–14
14	Muriate of Potash	120	184	12–16		
15	Superphosphate	230	150	10	187½	12–30
16	Superphosphate	120	194	12–56		
17	Superphosphate	450	218	14–32		
18	Golden Harvest	*	210½	14– 2	202¾	13–31
19	Phosphate	*	195	13		
20	No Fertilizer	.....	198	13–12	198	13–12

* Record of amount lost in fire. Average of plots without fertilizer, 184 lb, 12 bu., 16lb per acre. Average of plots fertilized, 185 lb, 12 bu., 20 lb per acre.

In no case does the application of fertilizers show an increase of over three bushels per acre.

Average of plots without fertilizers, 285 lbs., 35½ bush. Average fertilized plots, 303 lbs., 37 bush. per acre. Plain superphosphate shows a gain of 5 to 7 bushels per acre. Toledo fertilizer shows a gain of 4 or 5 bushels per acre. Complete fertilizer a gain of 3 to 5 bushels per acre. Other fertilizers made but little apparent gain. Only plots having phosphates show increase.

Plaster and complete fertilizer each showed considerable gain, ten to fifteen bushels per acre. The St. Paul fertilizer, salt, lime and superphosphate, showed a slight increase. Nitrate of soda and muriate of potash showed but little effect—none beneficial.

Superphosphates produced a gain of only 2 to 4 bushels of flax per acre. No other fertilizer produced much more

than a bushel more on the average. Some seemed to actually lower the yield of grain.

TABLE II.

OATS AT WARREN.

Plot No.	Kind of Fertilizer.	Pounds per acre.	Oats. Pounds	Oats. Bush. per acre.	Average. Pounds	Average. Bush. per acre.
1	Golden Harvest	240	328	41	331½	41½
2	Phosphate	560	335	42		
3	Plain superphosphate	180	352	44	343½	43
4	" "	480	335	42		
5	No fertilizer	.....	300	37½	300	37½
6	Plaster or gypsum	175	297	37	288½	36
7	" "	525	280	35		
8	Nitrate of soda	220	281	35	266½	33⅓
9	" "	425	252	31½		
10	Muriate of potash	100	298	37¼	296	37
11	" "	180	294	36¾		
12	No fertilizer	.....	269	33½	269	33½
13	Complete fertilizer. Nitrate of soda	160	344	43	324½	41
	Muriate of potash	160				
	Superphosphate	320				
14	Complete fertilizer. Nitrate of soda	60				
	Muriate of potash	60				
	Superphosphate	120	305	30		
15	Lime	120	282	35¼	282	35¼
16	Salt	320	276	34¼	295½	37
17	"	195	315	39½		
18	No fertilizer	Lost	.....	.....	.....	.....

RESULTS AT WARREN.

The soil at Warren is one of great native fertility, lays nearly level, and being underlaid with clay subsoil, is wet in years of unusually large rainfall. The bad effects of too much rain are obviated by means of ditches around the quarter sections. Into these ditches dead-furrows, made broad and deep by plowing the land the same way for successive years, and following the direction of the greatest incline, conduct the surface water when heavy rainfall occurs. The season previous having been a dry one, and the rainfall being rather favorable, our crops had fairly good conditions as to moisture. This land had been cropped to wheat for ten years or more, with an occasional summer fallow, and once laid in timothy pasture for two years. It is a typical Red River Valley soil, but has had better management as to allowing and keeping down weeds than most lands in that

region which have been for so long a time under the plow. The grain was planted on fall plowing, the land having produced wheat the previous year. The grain was sowed with a press drill, and the land was not even harrowed before or after the sowing. The crust formed on the soil during the winter was thus left intact, except where broken by the press

TABLE III.

BARLEY AT WINDOM, 1890.

Plot No.	Kind of Fertilizer.	Pounds per acre.	Barley. Pounds	Barley. Bush. per acre.	Average. Pounds	Average. Bush. per acre.
1	Land plaster	375	Not threshed			
2	Tankage, St. Paul	120	546	45½	474	38½
3	" "	280	401¾	33½		
4	No fertilizer		341½	28½	341½	28½
5	Salt	40	435½	36¼	477	39½
6	"	160	519	43¼		
7	Lime	160	463¼	38½	444	37
8	"	320	425	35½		
9	No fertilizer		461	38½	461	38½
10	Plaster or gypsum	40	458	38¼	536	45
11	" "	80	614	51¼		
12	Superphosphate	160	414	34½	445	37
13	"	80	476	39¾		
14	No fertilizer		352½	29¼	352½	29¼
15	Muriate of potash	80	342	28½	341	28⅓
16	" "	40	339	28¼		
17	Nitrate of soda	80	334	27¾	319	26½
18	" "	40	303¼	25¼		
19	No fertilizer		337	28	337	28
20	Complete fertilizer	320	584¼	48¾	564	47
21	" "	160	544	45¼		
Average of plots with no fertilizer			373			31
Average of plots fertilized			423½			35¼

wheels and by the feet of the horses, thus preventing the wind from "blowing" the soil badly. When harrowed, and especially if rolled, in this region, the fine mellow soil is carried off in great quantity by the strong winds in spring, if there is not ample rainfall to keep it moist. The fertilizers in this case were scattered in the drills with the grain by means of a fertilizer attachment on the Havanna Press Drill. This put the fertilizer in very close contact with the seeds, but no injurious results were shown by the appearance of yellow plants or otherwise, even when the fertilizers were put in unevenly in a few places to see if a greater quantity seemed to have injurious effects. The fertilizer attachment

used was an entirely new feature on the Havanna Press Drill, and excepting one small defect which is easily remedied, it worked admirably. Our thanks are due to the manufacturers, Stoddard Mfg. Co., Dayton, O., for their assistance, and for the use of their machine. Seed wheat and oats grown on March & Spalding's farm the previous year was used. Like most grain in that locality of the crop of 1889, it was not first class in quality. The plots contained one-

TABLE IV.

FLAX AT WINDOM, 1890.

No.	Kind of Fertilizer.	Pounds per acre.	FLAX.		Average.	
			Pounds per acre.	Bush. per acre. bu. lb.	Pounds per acre.	Bush. per acre. bu. lb.
22	Salt	160	107	7–36	144	10–17
23	Salt	40	181½	13		
24	Land Plaster	80	185½	13–14	192	13–40
25	Land Plaster	40	198½	14–10		
26	No Fertilizer		204½	14–32	204	14–32
27	Superphosphate	160	214	15–16	233	16–37
28	Superphosphate	80	252½	18		
29	Muriate of Potash	80	208½	14–50	207	14–44
30	Muriate of Potash	40	205½	14–38		
31	No Fertilizer		167½	12	167	12
32	Nitrate of Soda	80	160	11–24	174	12–25
33	Nitrate of Soda	40	188½	13–26		
34	Complete Fertilizer	320	180	12–48	185	13–14
35	Complete Fertilizer	160	191	13–36		
36	No Fertilizer		190	13–32	190	13–32
37	Lime	160	193	13–44	200	14–18
38	Lime	320	208	14–48		
39	Tankage, St. Paul	130	187	13–20	187	13–20
Average of plots without fertilizer					187	13–20
Average of plots fertilized					191	13–36

fourth of an acre each, and were fifty-four rods long by two seeders, about twelve feet, wide. The ordinary crop of wheat in this region when first settled was twenty-five bushels of No. 1 Hard per acre. The fact that even complete fertilizers produced a gain of not more than two bushels per acre of wheat and five bushels per acre of oats, indicates that the lessened yields of latter years is due mainly to causes other than a lack of fertility. In fact the general results of these experiments seem to strongly indicate that this soil is very rich, and that no general economical effect came from the use of these expensive fertilizers when applied to these small cereals. Thirty bushels per acre in 1892 has further

shown the owners that their lands need no fertilizers if climatic conditions are favorable to wheat.

RESULTS AT WINDOM.

The soil at Windom is a rich, nearly level prairie loam underlaid with a pervious clayey subsoil. It had been under cultivation for a dozen years or more, but being at some distance from barns had never received any dressing of barnyard manure. The barley and flax planted here were drilled in with a Missouri grain drill, and the fertilizers at once drilled into the same plots. Plot I, on which land plaster was sown on the barley was so badly grown to weeds that it was not harvested. A few rods at the south end of barley plots 13, 14 and 15, also on 20 and 21, had been slightly manured from straw stacks which had been partially burned and partly allowed to rot there a few years before. The barley here was down and badly affected with rust. On the flax plots, Nos. 22, 23, 33, 34, 35, 36, 37 and 38, the flax died in very small spots where a former straw stack and two "low placed" caused the soil to be unsuited to the plants. No estimates of the size of these small dead patches have been preserved, so the tabular statement is faulty in that it is not corrected for the slightly lessened area in these plots. On inspecting the tables and the notes underneath, it will be observed that there is no general large increase in yields per acre by the use of commercial fertilizers. Some of the land plaster and complete fertilizer plots of barley seem to have been benefited. The general effects are but slight.

RESULTS AT TAOPI.

At Taopi the wheat and barley were sown on land that had been cropped mainly to wheat for nearly twenty years. Oats had been grown in alternation with the wheat a few times, and once the land had for a few years grown crops of timothy hay or timothy seed. As before stated records of yields were lost in the fire. This was especially unfortunate as on this older land that had been somewhat worse worn, and was not as rich originally as the vergin soil at Warren or Windom, the fertilizers would have had a little better chance to show profits. A few results which were especially

marked can be remembered. Nitrogenous manures made much greater growth of straw, both in case of the barley and the wheat. Tankage from South St. Paul also gave much larger yield of straw, doubtless due in the main to the nitrogen it contained, as no other fertilizer made any marked increase in the size of either wheat or barley plants. There was considerable more effect of the fertilizers shown here than at either of the other two places, but memory alone is not sufficient for reliable records. There was an increase in the grain, though not great. This, however, is true, that none of these fertilizers at Taopi caused the old-time yield of wheat, though the season was favorable as to the amount of rainfall. And the conclusion is safe that in Mower County, where the wheat has failed for most years during the past decade that fertilizers alone, with other conditions as they existed, would not bring the success with wheat that was experienced when that county was first settled.

Mr. H. H. Crosset of Taopi, made a trial of a so-called "wheat Phosphate," a complete fertilizer, sent him from Ohio by the proprietor of the farm, Mr. Chamberlain, with the following results:

1. Plowed in fall and in spring, 250 lbs. fertilizer per acre, yield 3,875 lbs. grain on whole plot.

2. Plowed in fall and in spring, no fertilizer, yield 2,558 lbs. grain on whole plot.

3. Plowed in spring and in fall, no fertilizer, yield 2,903 lbs. grain on whole plot.

OUR SOILS AND THEIR FERTILITY.

When the lands of any state are so reduced in fertility that commercial fertilizers are needed, and will repay their expense, the farmers are forced to study the science of manures. If they remain ignorant and use fertilizers, they annually spend great sums of money on expensive fertilizers with delusive names, sold them by shrewd dealers, who make large profits. Chemists and botanists have worked out many facts regarding the science of supplying plant food to soils, and with a knowledge of these truths the farmer need not go far astray. Minnesota is not as yet in condition for the general farmer to make any money out of the use of commercial fertilizers, though in some cases land plaster might pay on clover, or even other crops, especially on the lighter or sandy soils. This fertilizer is cheap, costing only $3 per ton by the carload at Minneapolis. Tankage from our home stock yards, which is offered at $10 to $15 per ton, can doubtless be used with profit by some of our gardeners who are too far from city sources of barnyard manures, and who have light or rather poor soils. These two fertilizers will doubtless be the first that are used in our state. Wherever a proper system of rotations is observed, the rich lands, like those upon which our experiments have thus far been conducted, will remain so rich for some time, especially if crops are intelligently rotated, that expensive fertilizers will not pay. The larger part of soils now under cultivation in Minnesota are rich, and a great portion of that uncultivated also has a very large amount of native fertility. There is, however, much land in the state which is too sandy to have stored up a very great amount of plant food. Other lands which lack in native fertility are not in very great quantity; some are too nearly clay; others, in the southeastern and in the northeastern portion, are on original rock foundation, and in places have not enough fertility to support continuous large crops for many years. Fertil-

izers will doubtless come into use on these poorer lands, but except for fruit and garden crops, which cost much in labor per acre and return large income per acre, they will not pay so long as lands not needing expensive fertilizers can be had as cheaply as now, and so long as stable manure is no more expensive than at present. The amount of lands in this state, dotted with lakes as it is, which are too wet for cultivation without artificial drainage, is also considerable. These wet lands are in nearly all cases full of fertility, and when drained with surface drains, or far better with tiles, they are our very richest soils. They will even serve as mines of fertility from which we can grow crops to be made partly into manure for other and poorer parts of our farms.

SOME GENERAL FACTS ABOUT FERTILIZERS.

While the science of feeding plants is extensive, and the literature relating to it very voluminous, a few of the more general facts and principles will here help to make clear our method of experimenting to solve the numerous questions which come up regarding how to best raise wheat and other crops.

As all matter is divided into about seventy-five elements of which all the numerous compounds both inorganic, without life, and organic, built up in living organisms, are made, we naturally seek first those elements which make up the composition of plants. It is found upon analysis that oxygen, hydrogen, carbon, nitrogen, phosphorous, potash, soda, lime, magnesia, silica, sulphur and traces of a few others are the elements of which all plants are composed. Of these the first three, oxygen, hydrogen and carbon, are obtained mainly from the air, directly or indirectly. Water which is composed of hydrogen and oxygen is supplied by the atmosphere to the soil, where the plant roots take it up. The carbonic acid, which is composed of carbon and oxygen, is thinly mixed throughout the air, and when the plant is growing rapidly this gas diffuses toward the leaves and is there used by the plant cells. Thus where moisure is abundant plants can get all they want of oxygen from both these sources and of hydrogen from the water and of carbon from this carbonic gas which is a part of the air, and we need not

supply these three elements to the plants in manures even on the poorest soils. Nitrogen is in the air in very great quantity, and continually in contact with the plant, yet the plant can make no use of the atmospheric nitrogen. It is in the free state in the air, that is it is not in a compound with other elements, and the plants can not take it pure. There is also some in the air, in the compound called ammonia, but the plant leaves are unable to use this also. The nitrogen must be in some compound like nitrate of soda and be in solution in the soil-water around the roots or the plant cannot use it and there must be considerable of it present for crops to do well. Soils often become deficient in nitrogen, when better crops are raised if some manure containing a soluble nitrogen compound is applied. This, then, is one element, the need of which we wanted to determine in our wheat lands. To determine if the soils needed nitrogen we applied nitrate of soda alone and also in mixtures with mineral manures. We also applied tankage, which contains a large amount of nitrogen. The four elements above named, viz: oxygen, hydrogen, carbon and nitrogen, are called the volatile plant elements, as they go off in the form of vapor when the plant is burned.

The several other elements above named, viz: potash, phosphorous, soda, lime, magnesia and silica, together with traces of iron, chlorine, etc., are called the mineral or ash, as they remain as ashes when the plant is burned. These, like the nitrogen, must all be in the soil in soluble compounds so that they may be taken up by the roots of the plants out of the moist soil. Some of these ashy materials are not necessary in large quantities in the soil. In fact, none but potash and phosphorus are needed in greater quantity than is found in almost all soils. The soils of nearly all of Minnesota are made up of glacial material, which is composed of many kinds of stones and clay mixed together, thus supplying all the kinds of mineral food for plants. In some cases, however, where the various parts of this mixed glacial till were assorted out by water, and clay left in one place, sand in another and gravel in another, there may be a lack of one or more of these elements; but most of the land

of the state now being cultivated is made up of that mixture of clay, sand, gravel and stones, which, as they decay or decompose into soil, supply all the ash elements plants need.

This same glacial mixture, not too dense and impervious as tough clay or loose and leachy, as gravel or sand, is also best to hold the proper amount of moisture in readiness for plants and lets in air to decompose its own particles, and best serves as a storehouse to hold easily soluble nitrogen compounds. It also gives the best conditions for soil microbes. But from the experience of all other investigations we can assume that potash and phosphorous are the ashy elements most needed, if any are wanting. Some mere theorists have said that our great crops of wheat have taken so much silica out of our soils that they no longer have enough soluble silicates to make stiff, bright straw like that grown when the land was new. But this glacial drift mixture, of which most of our soils are made, certainly contains an over abundance of silica. Besides the dull colored straw is as common on new lands, in older settled neighborhoods, as on fields cropped for one or two decades. Confining our experiments on mineral manures mainly to potash and phosphorous we applied the former in the form of muriate of potash (K Cl), mined in Germany, the latter in the form of prepared South Carolina phosphatic rock, or superphosphate of lime [Ca H 4 (P O 4) 2] and we found no general large benefit from the application of these substances. Phosphatic manures had a slight general beneficial effects, but not nearly enough to pay for the cost.

These several elements which plants use are often in the soil in insoluble compounds or in a condition in which the plant can not use them. The potash, for example, may be there in abundance as a constituent of stony particles but not enough of it soluble so that the plants can procure all they need. So the nitrogen may be there in the form of undecayed plants or manure and not be available to the crop. And the fact is, that only a small part of these elements in the soil is at any one time in soluble forms, but the wise provision of nature is for the insoluable part to gradually become soluble thus giving out to growing crops a con-

stant supply. We call the soluble part of the nitrogen, for example, available nitrogen and that which is tightly locked up in the soil the insoluble or non-available nitrogen. Ordinarily the atmosphere, the sun, the rain, low organisms and the chemical reactions which go on in the soil, assisted by cultivation in the presence of the plant roots, are depended upon to dissolve and make ready enough of the insoluable substances to keep the plant constantly supplied. But in some instances it is found that help is needed to keep up a good supply of one or more of these elements. This help is often given by putting on some active substance like lime, land plaster, or salt which are usually not needed as food by the plant, but which act chemically upon the insoluble potash, nitrogen or phosphorous making it soluble and available to the crop. To see if any good could be done by the use of these "indirect fertilizers" salt, lime and land plaster were all tried at the three places where the experiments were performed. The results show that the soils at Warren and Windom are rich in all kinds of fertility. At Taopi the older, poorer soil used was not very rich in nitrogen and the fact that continued cropping to small grain crops is "wearing it out" is plainly seen.

An extended study of the chemical composition of the soils of the wheat fields was begun. But little progress has been made in this line as not only were part of the samples which had been gathered destroyed by fire but the chemical outfit was likewise lost. The newly erected chemical laboratory furnishes accommodation much more nearly suited to the needs of this work than did the building formerly used.

CONCLUSIONS.

The one fact most prominently brought out is that our better lands are very rich in all kinds of plant food even after having grown crops of wheat for ten to twenty years. Neither nitrogen, potash, nor phosphoric acid when purchased in commercial fertilizers will pay on grain crops on these rich lands. Not even land plaster, salt or lime will generally return their cost in increased crops while our lands are so rich. In short the time for the general use of commercial fertilizers, purchased in markets where we must compete

with gardeners and farmers on the worn out farms of older states and other countries, has not come.

Farmers who have thin, much worn land should experiment with land plaster and with tankage. The expensive forms of nitrogen, potash and phosphatic fertilizers will not pay as yet in our young state. Much barn-yard manure rich in all these elements of fertility should be made, husbanded and intelligently applied to those crops which will get from them the greatest benefit. They not only make the soils richer but keep them moister. We have wonderfully rich soils, it is wisdom and should be our pride to keep them rich.

The lessened crops of wheat and other cereals comes mainly from causes other than a lack of plant food in the soil. Rusts, unfavorable climatic conditions as to moisture, hot winds, hot sun, etc.; chinch bugs; land foul with weeds; too loose mechanical condition of the soil, and poor seed are some of the things which have done far more to lessen wheat yields than a lack of fertility. The study of some of these is of far more present importance than soil analysis or fertilizers trials.

UNIVERSITY OF MINNESOTA.

Agricultural Experiment Station.

BULLETIN No. 21.

JUNE, 1892.

I.—SUGAR BEETS. II.—SORGHUM.

☞ The Bulletins of this Station are mailed free to all residents of the State who make application for them.

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.

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SUGAR BEETS.

D. N. HARPER.

The production of Beet Sugar has been attempted in this country many times and in various places. Within the past few years it has proven successful in California and is now being carried on also in Utah and Nebraska.

Since 1830 it has been a very profitable industry in Germany, Austria and France, and more recently in various other European countries. While the natural conditions in various parts of this country are more favorable to the production of beets and the manufacture of sugar from the beets than they are in any of the European countries the industry cannot yet be said to be fairly established here.

During the past four years experiments have been made by the Experiment Station as to the adaptability of the climate and other conditions of Minnesota to the production of good beets. Each year the results have been reasonably satisfactory. The experiments of 1890 were so encouraging and promised so much that it was deemed advisable to make very extensive tests during the following year.

Seed was imported in considerable quantity from Germany and distributed, with the kindness of the railroads, free, to about twenty-five hundred farmers in all parts of the state, together with instructions for the planting, cultivation, and harvesting of the beets. The railroad companies very kindly permitted free transportation of samples of the crop from all farmers who would send the same in, and the State Agricultural Society provided premiums for the best fifteen samples.

Owing to the disturbed conditions of the Experiment Station, the delivery of the seed was very much delayed and a large part of it sent out failed to reach the farmers in time for planting. There were, however, a great many

who returned beets for analysis, and a statement of the results is given in the following pages.

The work upon the State farm was arranged to show the cost of production, the yield per acre, the quality of the beets as affected by cultivation, and to test the use of various machines in the planting and cultivation of the beets. As it was to be expected, the beets grown upon the farm were much better than those produced anywhere else.

In the last sugar beet bulletin published, it was stated that the establishment of the beet sugar industry in this country depends chiefly and primarily upon the farmer. The results of last year gave renewed evidence of this.

Upon the State Farm the results as to the quality of the beets were all that could be expected, and show that we possess the conditions necessary for the production of the best beets for the purpose of sugar manufacture. While the results elsewhere in the state vary greatly, this variation is chiefly due to the difference in cultivation given.

Many farmers had the mistaken idea that it was necessary to have highly manured lands in order to grow good beets. This, it was pointed out in the last bulletin, is just what we must guard against. The best lands in our state for the raising of beets are those lands which have been cropped for a considerable number of years to grain, and are what may be termed our "worn out" lands. By careful production of beets these can be restored to their native fertility.

The detailed results of analyses are as follows:

All the analyses of sugar beets recorded in the following tables were made by Mr. John Thompson, assistant in the chemical laboratory at the station.

ANOKA COUNTY.

Town	Name of Party.	Variety	Date Analyzed	Sugar Per Cent.....	Purity Per Cent.....	Sugar Per Ton.....	Avg. Weight of Beets. Oz.
Anoka	John Hunter	Vilmorin White Improved	October 26	15.5	64.9	310	10
"	" " "	" " "	November 6	14.6	77.6	292	16
"	C. E. Merrill		November 12	10.5	77.2	210	25

BECKER COUNTY,

Frazee City	J. M. Schlehr		November 4	11.9	71.3	238	18

BLUE EARTH COUNTY.

Mankato	W. R. Veigel		October 23	10.9	81.4	218	53
do	J. S. Darr		do do	11.0	71.4	220	32
do	Frank Holste		do do	11.6	77.3	232	32
do	M. J. King		do do	9.65	63.8	193	34
do	L. A. Foster		do do	10.2	70.3	204	29
do	Jno. Danber		do do	8.6	66.7	172	32
do	J. J. Stephens		do do	9.3	67.9	186	35
do	Wm. Phillips		do do	10.5	74.1	210	40
do	M. Sherer		do do	9.8	69.0	196	29
do	Asa McCallon		do do	8.7	70.0	174	32
do	J. M. Davis		do do	10.4	69.8	208	23
do	David E. Evans		do 24	7.5	65.2	150	75
do	Thos. V. Davis		do do	10.8	72.0	216	37
do	J. O. Smith		do do	12.9	78.7	258	22

BLUE EARTH (*Continued.*)

Town.	Name of Party.	Variety.	Date Analyzed	Sugar per cent.	Purity per cent.	Sugar per Ton.	Avg. weight of beets. Oz.
Mankato	Aug. Dusterkoff		October 24	10.5	71.9	210	32
do	Henry Knoff		November 7	11.6	73.9	232	40
do	M. Uhlman		do do	10.3	72.6	206	18
do	M. J. King		do do	12.1	75.7	242	20
do	G. Darr	French Very Rich	October 14	11.95	76.9	239	
do	J. J. Stevens		November 7	11.5	73.7	230	36
do	Norman Beebe		do do	11.8	76.6	236	32
do	Ferdinand Walzen		October 23	9.6	66.2	192	26
do	Wm. Mason		do do	9.1	69.4	182	35
do	T. A. Becker		do do	10.8	71.1	216	32
do	C. A. Goodrich		do do	13.6	82.9	272	21
do	Mike Uhlman		do do	10.1	71.1	202	56
do	D. R. Brooks		do do	11.6	72.0	232	32
do	Wm. Hemecke		do do	12.4	76.1	248	25
do	M. Hynson		do do	12.5	79.1	250	21
do	Geo. McKee		do do	10.5	75.6	210	32
do	George Arnold		do do	8.1	62.8	162	48
do	Chas. Farm		do do	10.9	74.7	218	36
do	M. J. King	French Very Rich	November 7	12.2	76.2	244	24
do	Wm. Heinecke		do do	14.5	81.0	290	24
do	W. R. Veigel		do do	13.8	75.4	276	25
no	Frank Halstad		do 9	14.0	74.0	280	40
do	J. M. Davis		do do	14.5	76.3	290	18
do	L. S. Foster		do do	14.1	78.4	282	21
do	Alex Roach		do do	12.8	81.5	256	33
do	C. H. Goodrich	Vilmorin White Improved	do do	12.0	75.5	240	40
do	G. Darr		do do	13.2	79.5	264	8
South Bend	Chris. Hammel		October 23	11.8	76.6	236	16
	J. A. Jones		November 17	11.3	70.0	226	26

BROWN COUNTY.

New Ulm	A. Manderfield		November 3	13.6	75.6	272	18
do do	H. L. Runk		do 12	16.4	77.0	328	24
do do	H. Miller		do do	11.7	69.0	234	12
do do	Thos. Klippsbein		do do	16.4	79.2	328	19
do do	Jas. Schuller		do do	14.5	77.5	290	16
do do	Jno. Hanenstien	White Improved	do do	15.0	79.8	300	20
do do	Andrew Becker	Dippe's Kleinwanzleben	October 21	14.3	80.8	286	13
Springfield	Dan'l Burns		November 3	11.1	71.2	222	12
do do	S. P. Bently	Dippe's Imperial	do do	13.2	77.6	264	20

CARLTON COUNTY.

Mahtowa	John Stkinson		October 5	13.54	84.4	270.8	
do	M. Paderson		do 7	10.86	80.4	217.2	
do	Chas. Christenson		do 14	12.9	79.7	258	
Moose Lake	Frank Ekman		do 24	11.1	76.3	222	27
do do	Peter Force		November 3	12.2	77.6	264	21
do do	L. S. Gotchier		October 8	13.05	81.2	261	20
do do	Chris. Rahlf		do 10	10.93	75.7	218.6	
Barnum	J. H. Kahring		do 24	14.0	83.3	280	18
do	J. Murphy	Dippe's Imperial	do do	14.8	83.1	296	18
do	Walt & Gardahl		do do	11.6	78.9	232	18

CARVER COUNTY.

Carver	W. G. Japs	Vilmorin White Improved	October 26	13.7	80.1	274	24
do	H. Muhlberg	Vilmorin White Improved	do 24	6.5	60.2	130	25
do	C. Jobs		November 7	14.6	80.7	292	23
Norwood	Aug. Hoeffken		October 26	12.15	76.2	222	18

CHISAGO COUNTY.

Rush City	John Briet		November 3	13.2	73.7	264	10
do do	Martell Johnson		do do	13.1	77.5	262	20
do do	Fred Marty		do do	11.5	75.7	230	31
do do	Napoleon Young		do do	12.2	75.3	244	27

CHISAGO COUNTY (*Continued*).

Town	Name of Party	Variety	Date Analyzed	Sugar per cent.	Purity per cent.	Sugar per Ton.	Avg. weight of beets. Oz.
Rush City	John Berg		October 24	13.9	81.3	278	36
Harris	L. J. Stark		do 17	12.55	77.8	251	49
do	Jno. Jarchow		November 3	14.0	79.1	280	20
North Branch	Jno. Sjohohn		October 31	13.9	88 3	278	18
South Branch	A. Rice		do 24	12.0	77.9	240	7
Centre City	J. H. Magry		do 7	13.23	80.0	264.6	.....
do do	Chas. Andrews		do 15	13.4	85.1	268	.....
Lindstrom	A. Wallmark		November 3	13.6	81.9	272	20
Taylor's Falls	Alais Aydt		October 14	12.25	81.5	245	.....
do do	John Peterson		do 24	12.25	76.8	245	11
Pine City	Lambert Bros.		November 3	13.2	73.7	264	19
Stacy	Fred Lendt		October 14	12.6	81.8	252	.....
Stacy	Jessie Brom		do 3	13.33	88.7	267	.....
Stacy	Harry Lendt		do 9	13.9	81.8	278	.....
Chisago City	John Ekstrom		do 24	13.3	83.1	266	12
do do	Aug. Lofgren		do do	14.3	88.9	286	23
.....	.....	.....	do do	13.8	81.2	276	9

CLAY COUNTY.

Sabin	Geo. Fredericks	Dippe's Vilmorin Improved	October 15	12.57	78.8	251.4	.....
do	G. K. Rozel		do 24	14.9	88.7	298	20
Georgetown	Jacob Wamback		do 27	10.2	73.1	204	17
Muscoda	T. B. C. Evans	Dippe's Vilmorin	do 21	11.85	77.8	237	18
Morehead	P. Eastland		November 7	12.2	76.2	244	24
Kragnes	Chas. Brendemeuhl		do 7	10.2	68.0	204	58

CROW WING COUNTY.

Brainerd	Geo. Kirtland	Kleinwanzleben Elite	December 1	17.1	88.6	342	24
Brainerd	do do	Zuckerreichste	do do	18	92.8	360	17

COTTONWOOD COUNTY.

Windom	S. Huntington		October 15	10.0	72.5	200	

DAKOTA COUNTY.

Randolph	H. Matz		October 27	15.2	88.9	304	18

DOUGLAS COUNTY.

Alexandria	Moses Robinson	Dippe's Vilmorin Improved	November 3	14.4	80.9	288	16
do	John Donner	Dippe's Vilmorin	do do	10.9	73.7	218	16
do	Jas. F. Heibel		October 24	14.0	80.0	280	8
Osakis	Wm. McCartney		do 8	10.64	78.5	212.8	
Evansville	R. Amonson		do 26	10.6	73.6	212	29
do	John McForlane	Dippe's Vilmorin Improved	do 24	11.4	75.0	228	32

FAIRBAULT COUNTY.

Wells	Jno. Penny	Vilmorin White Improved	October 10	12.0	75.0	240	24

FREEBORN COUNTY.

Hartland	Jas. Lonergan		October 26	11.5	77.8	230	

GOODHUE COUNTY.

White Rock	W. A. Westerson	Dippe's Imperial	November 7	13.6	79.1	272	31
Hay Creek	A. Burkhard	German	do 20	13.5	69.7	270	34
do do	A. Burkhard	Little Wang	do do	14.3	77.3	286	24
do do		French	do do	15.0	83.3	300	16
Goodhue	Rev. I. Finney	Vilmorin White Improved	December 19	17 8	83.6	356	18

GOODHUE COUNTY (*Continued*).

Town	Name of Party	Variety	Date Analyzed	Sugar per cent.	Purity per Cent.	Sugar per Ton.	Avg. weight of beets. Oz.
Red Wing	W. Hayman	Dippe's Kleinwanzleben Elite	October 17	12.1	77.6	242	19
do	J. F. Porter	do do do	November 7	14.5	83.3	290	15
do	J. F. Porter	Dippe's Vilmorin Improved	do do	16.2	85.9	324	14
do	J. F. Porter	French Vilmorin Improved	do do	16.7	85.8	334	14
do	Wm. Danforth		October 27	12.0	77.9	240	25
do	C. A. Sergent		do 26	13.6	85.0	322	9
do	Chas. Welt	Dippe's Kleinwanzeleben	do 31	13.6	76.8	272	17
do	Joshua Allyn	Vilmorin White Improved	November 7	11.5	72.8	230	26
do	do do	do do do	do do	13.2	73.9	262	36
do	E. T. Gove	do do do	December 1	16.1	82.6	322	16
do	Fred Walker	do do do	do do	15.4	75.1	308	16
Zumbrota	J. F. Mitchell		October 5	10.1	66.6	202	
do	A. K. Pengilly		do 31	14.1	88.7	282	18
do	Post office Mazeppa, Wabasha Co.		do 31	14.0	80.5	280	16
do			do 31	11.9	75.8	238	29.5
Dennison	G. M. Matcher		November 12	12.8	72.3	256	35
Red Wing	H. M Slee		October 17	16.2	86.6	324	7
	K. B. Norswing		November 20	14.5	80.1	290	18

GRANT COUNTY.

Hereford	Nick Thies		October 27	8.9	60.8	178	18
Elbow Lake	O. P. M. Hoffman	German	do 17	9.9	74.4	198	23
do	O. P. M. Hoffman	Dippe's Vilmorin	do do	10.8	75.0	216	8
do	John Peterson	Dippe's Vilmorin White Imp'd	November 14	15.1	78.3	302	26
do	O. L. Lofsvold		October 17	9.8	73.7	196	24
Ashby	N. O. Puntches	Dippe's Vilmorin White Imp'd	November 4	14.5	80.6	290	26
do	F. Wahldieck	do do do do	October 27	11.7	75.0	234	13
do	S. J. Beebe		November 4	13.2	76.7	264	16
Norcross	Aaron Watson	Dippe's Vilmorin	October 14	9.7	73.5	194	

HENNEPIN COUNTY.

Excelsior	W. B. Mason	Vilmorin Improved	November 9	13.2	78.6	264	17
Richfield	Wm. Ray		October 26	14.5	79.7	290	17

JACKSON COUNTY.

Jackson	Jas. Patterson		November 9	9.9	71.2	198	23

KANDIYOHI COUNTY.

Willmar	P. P. Eddy	Vilmorin White Improved	November 14	17.7	80.2	354	16
St. Johns	O. D. Hong		October 31	16.1	90.9	322	14

KITTSON COUNTY.

Kennedy	J. F. Dahlgreen		October 28	13.0	80.7	260	21
do	Jno. Rice Bro.		do 17	13.3	82.1	266	13
St. Vincent	W. A. Adams		November 7	11.9	75.4	238	26
do	Not given		do 9	11.6	72.0	232	18
do	J. B. Hutchins	Dippe's Imperial	do 7	14.8	80.4	296	12
Hallock	Jas. Gillie		October 26	11.1	78.8	222	14
do	Sam'l Jolliff		November 4	13.1	75.8	262	20
do	do do		do 9	13.2	88.0	264	10

LAC QUI PARLE COUNTY.

Madison	P. Hasland		October 27	14.9	83.2	298	10
do	C. H. Siljam	French, Very Rich	November 16	14.0	80.9	280	28

LE SUEUR COUNTY.

Montgomery	E. A. Kauffer	Kleinwanzleben	November 7	15.8	78.2	316	16
Le Sueur	Wm. Weil		do 12	15.5	80.7	310	12
do	Jerry Shea		do do	12.6	72.4	252	17

LE SUEUR COUNTY. (*Continued.*)

Town.	Name of Party.	Variety.	Date Analyzed	Sugar per cent.....	Purity per cent.....	Sugar per Ton.....	Avg. weight of beets. Oz.
Le Sueur	H. Cantwell		November 3	13.9	78.6	278	24
do	H. T. Otting		do 3	13.9	81.8	278	11
do	H. Rethwell		do 12	14.0	76.1	280	32
do	Fred Prion		do 12	14.4	74.2	288	16
Sibley	F. Prion		do 3	13.5	75.9	270	16

MARSHALL COUNTY.

Warren	J. H. Haggard		November 11	12.3	75.5	246	15
do	P. A. Peterson	Vil. White Improved French	October 27	14.1	84.4	282	16
do	James Coler	Dippe's Vilmorin Improved	November 11	14.6	83.4	292	12
Stephen	W. E. Calbertson		October 31	10.0	69.0	200	24
Argyle	A. Johnson		do 26	9.4	68.6	188	36

MARTIN COUNTY.

Sherburne	H. M. Barnes		October 21	12.3	74.5	246	26
do	Swan Olson		do 27	8.2	64.6	164	36
do	B. F. Meetch	Vilmorin White Improved	do 26	13.8	81.7	276	21
Fairmont	J. E. Cansight		do 27	10.4	71.7	208	32
Fairmont	Mrs. Jonah Smith		November 4	10.2	71.8	204	16

McLEOD COUNTY.

Hutchinson	Wm. Tomlinson		October 15	10.8	74.0	216	
do	H. V. Bonnicoell		do 31	12.7	76.0	254	27
do	B. F. Pettijohn		do 21	11.25	76.8	225	28
do	W. W. Pendergast		do 21	13.0	79.3	260	19
do	Jesse Pettijohn		do 21	8.8	73.9	176	18

Hutchinson	L. Tomilson		October 21	9.3	74.4	186	20
do	Wm. Tomilson		do do	12.0	68.9	240	17.5
do	Peter Weiss		do do	14.7	81.7	294	28
do	Dan'l Devitt		do do	13.1	82.9	262	28
do	C. A. Wagner		do do	11.7	77.0	234	44
do	L. W. Ells		do do	11.1	75.0	222	21

MEEKER COUNTY.

Watkins	John Hapel		October 13	15.65	85.3	313	

MURRAY COUNTY.

Slayton	H. G. Day		October 14	10.25	75.9	205	
do	J. Sharp	Dippes Kleinwanzeleben.French	November 3	11.6	72.0	232	17
do	do	do do German	do do	11.7	73.2	234	17
do	do	Zuckerreichste Elite	do do	12.2	78.2	244	18
do	do	Vilmorin White Imp., French	do do	12.4	76.1	248	18
do	do	Dippe's Imperial	do do	12.1	76.6	242	16
do	do	French, Very Rich	do do	10.4	73.8	208	21
do	do	Vilmorin White Improved	do do	12.6	75.9	252	19

NICOLLET COUNTY.

St. Peter	A. Nelson		November 3	13.6	79.1	272	21

NOBLES COUNTY.

Worthington	D. Foss		October 14	12.65	77.9	253	
do	Allen Chancy		November 3	14.4	77.4	288	16
do	do do		do do	11.5	69.0	230	16
do	J. P. Madson		October 21	10.8	75.5	216	17

NORMAN COUNTY.

Town.	Name of Party.	Variety.	Date Analyzed	Sugar per cent.	Purity per cent.	Sugar per Ton	Avg. weight of beets. Oz.
Perley	H. O. Bergh	Dippe's Vilmorin Improved	November 14	13.3	82.1	266	33
Lockhart	J. D. McPhee		do 4	11.1	72.6	222	52
Lockhart	Aug. Menge		do 9	13.4	76.1	268	19

OTTER TAIL COUNTY.

Elizabeth	Wm. Brusewitz	Dippe's Vilmorin Improved	November 14	13.8	77.5	376	38
do	John Fick		do 14	11.9	76.8	238	40
do	Aug. Grimewald		do 16	13.9	79.0	278	38
Dalton	Lars Nelson		October 17	10.5	72.9	210	10
Carlisle	M. Lokken		do 2	7.82	64.2	156.4	
do	M. Hexum		do 2	10.57	73.1	201.4	
do	M. Lokken		do 31	11.5	72.8	230	21

PINE COUNTY.

Finlayson	F. M. Davidson		October 10	11.26	88.3	225.2	
Kettle River	Chas. Pederson		do 14	10.25	75.2	205	
do	N. Halstrand		do 14	11.8	77.1	236	
do	Val. Zovack		do 14	14.1	82.4	282	
Sturgeon Lake	not given		do 17	15.25	80.9	205	21
do do	E. L. Skogg		November 3	12.7	74.8	254	16
do do	Fred Swanson		October 8	8.32	65.5	166.4	
do do	John Swanson		do 9	10.95	77.5	219	
Hinkley	E. A. Hogen		do 14	12.15	77.7	243	
do	Michael Currie		do 9	11.39	78.6	227.8	

PIPESTONE COUNTY.

Edgerton	J. Pashbaugh		November 4	13.8	77.5	276	24

POLK COUNTY.

Fisher	A. C. Asseltine		October 15	10.6	72.6	212	
East Grand Forks	Ole B. Dahl		do 27	11.7	74.1	234	21
Crookston	W. H. Collins	Lane's Improved	do 21	9.65	77.5	193	34
Enclid	W. A. Veal	Dippe's Valmorin Improved	do 27	10.0	69.9	200	19

REDWOOD COUNTY.

Lamberton	Chas. Porter		November 4	13.6	76.4	272	24
do	Geo. Skelton		do 12	11.2	71.5	224	16

RENVILLE COUNTY.

Renville	Herman Prahl		do 9	12.5	76.3	250	18
Hector	F. Musil		October 14	12.3	79.9	246	
Olivia	J. A. Malhoun		November 7	13.1	73.7	262	20

RICE COUNTY.

Morristown	Seth H. Kennedy	Zuckerreichste	October 26	10.6	66.6	318	21
Northfield	J. J. Humry		November 11	15.2	80.4	304	3

STEVENS COUNTY.

Donnelly	Gus. E. Anderson	Dippe's Imperial	November 4	15.3	83.6	306	12

TODD COUNTY.

Eagle Bend	Alex Kap	Bultean Desprez	October 14	14.0	85.4	280	
Long Prairie	C. Horkins		do 27	12.0	77.9	240	24
do do	A. T. Nely		November 4	10.5	70.0	210	40

WABASHA COUNTY.

Town.	Name of Party.	Variety.	Date Analyzed	Sugar per cent.	Purity per cent.	Sugar per Ton.	Avg. weight of beets. Oz.
Mazeppa	H. L. Pengilly		October 31	13.0	76.9	260	21
do	do		do do	14.0	80.5	280	16
do	do		do do	14.1	88.7	282	18

WADENA COUNTY

Verndale	J. E. Anderson		October 24	12.0	78.9	240	17.5

WATONWAN COUNTY.

St. James	D. Sharp	Dippe's Imperial	November 20	13.0	80.8	260	20
do	Q. C. Rutherford	French, Very Rich	October 23	9.05	75.1	181	34
do	Swan Potwanson	Dippe's Vilmorin Improved	do 26	11.0	72.8	220	24

WRIGHT COUNTY.

St. Michaels	Peter Dehew		October 15	14.75	81.8	163.6	
do	G. D. Heuring	Dippe's Imperial	do 17	13.9	80.8	278	12.5
do	K. Hewring	do do	do 26	12.5	80.1	250	17
Howard Lake	W. J. Schimming		do 15	10.75	71.5	215	
do do				12	78.4	240	
do do				11.4	75	228	
Howard Lake				10.65	86.7	213	
do do				12	74.5	240	
Not given	Wm. Ricck		October 21	12	75	240	18
Cokato	Frank Griffith		September 28	14.21	81.1	284.2	
do	B. Griffith		October 2	12.52	76.3	250.4	
do	John Ekloff	Dippe's Kleinwanzleben	do 26	9.8	70	196	32
Clear Water	John Mitchell	French, Very Rich	do 28	12.9	79.7	258	19
do	O. Longworth		do 27	13	78.8	260	16

do	W. F. Rigby		November 4	13.6	81	272	16
Monticello	Jos. Perkins		October 28	12.65	74.7	253	17
do	E. D. Washburn		November 4	11.9	71.3	238	19
do	E. E. Walden		October 23	13.3	81.1	266	17
do	Jos. Bauman		October 27	11	78	220	21
do	Jos. Baumon		do 27	8.7	66	174	35
Delano	F. F. Chancellor		November 3	12.4	78.5	248	21
do	Olof Peterson	Kleinwanzleben	October 27	13.6	83.4	272	17
do	John Pomploon		do 27	9.4	67.6	188	30
do	John Sherry		do 27	12	75.9	240	26
do	C. Freckman	Dippe's Imperial	do 27	10.3	74.7	206	32
do	C. A. Rieder		do 27	12.4	76.1	248	26

YELLOW MEDICINE COUNTY.

Canby	C. G. Nelson		October 27	12.1	79.1	242	18
Granite Falls	H. M. Purdy		November 14	15.4	84.6	308	32

BEETS ON THE STATION FARM.

The analysis of beets raised upon the State farm recorded below were made from samples selected as follows:

On Sept. 26th, 28th and Oct. 1st, 5th, 7th, 9th and 13th, a lot of beets of each variety were pulled and mixed indiscriminately and averaged, leaving from three to five for analysis. Parts of each of these were rasped, the juice expressed under heavy pressure and analyzed.

The last fifteen samples on Oct. 13th and the samples of Dec. 2nd were taken from piles where all the beets had been placed by varieties.

The beets showed rapid improvement from the 26th until the 1st of October. On the 4th rain set in lasting several days resulting in a lowering of the percentage of sugar and purity, yet the averages still remained high.

The results are as follows:

DATE.	VARIETY.	SUCROSE.	PURITY.
Sept. 26.	.....	16.89	86.6
"	.....	16.77	88.3
"	.....	16.04	82.2
"	.....	16.87	80.3
"	.....	15.92	77.6
"	.....	17.11	81.5
"	.....	17.98	85.6
"	.....	15.18	77.8
"	.....	16.32	85.9
"	.....	15.80	79.
"	Knauer's Imperial.....	13.24	66.2
"	Zuckerreichste Elite.....	15.37	75.1
"	Vilmorin White Improved.....	16.22	85.4
"	Kleinwanzleben.....	16.94	84.7
"	Knauer's Imperial.....	15.50	77.5
	Average.....	16.14	80.9

DATE.	VARIETY.	SUCROSE.	PURITY.
Sept. 28.	.....	13.92	73.3
"	.....	16.36	81.8
"	.....	14.08	74.1
"	.....	17.09	87.7
"	.....	14.21	81.1
"	.....	16.58	80.9
"	.....	17.61	83.9
"	.....	17.99	85.7
"	.....	17.40	82.9
"	.....	15.92	81.6
"	Knauer's Imperial.....	15.64	78.2
"	Zuckerreichste	16.58	80.9
"	Vilmorin White Improved.....	15.33	80.7
"	Kleinwanzleben.....	16.33	81.7
"	Knauer's Imperial.....	16.58	82.9
	Average.....	16.11	81.1
Oct. 1.	Vilmorin White Improved	16.58	82.9
"	Kleinwanzleben	18.49	84.
"	"	17.67	84.1
"	"	17.34	82.6
"	Dippe's Improved.....	16.99	85.
"	Vilmorin White Improved	17.36	82.7
"	Dippe's Klienwanzleben.....	16.54	84.5
"	Vilmorin White Improved	16.67	83.4
"	Kleinwanzleben	17.98	92.2
"	"	15.67	84.7
"	Kleinwanzleben Elite	16.42	82.1
"	Kleinwanzleben	17.83	84.9
"	"	17.67	86.2
"	"	17.52	87.6
"	"	15.12	88.8
"	Zuckerreichste	16.77	88.3
"	Dippe's Kleinwanzleben	16.67	83.4
"	Kleinwanzleben	18.37	89.6
"	"	19.15	89.
"	Dippe's Kleinwanzleben	17.09	85.5
"	French, Very Rich	16.94	84.7
	Average.....	17.18	85.5

DATE.	VARIETY.	SUCROSE.	PURITY.
Oct. 7.	.....	13.51	84.4
"	.....	13.29	83.1
"	.....	14.33	89.6
"	.....	14.39	87.2
"	.....	16.11	94.8
"	.....	15.24	87.1
"	.....	14.23	79.1
"	.....	12.45	75.4
"	Kleinwanzleben Elite	13.54	79.6
"	Zuckerreichste Elite.....	14.71	86.2
"	Knauer's Imperial.....	13.29	83.1
"	Kleinwanzleben.....	13.26	78.
Oct. 9.	"	11.64	75.1
"	"	15.64	84.5
"	Zuckerreichste	14.23	81.3
"	Kleinwanzleben.....	15.58	82.
"	Vilmorin White Improved.....	16.90	84.5
"	Kleinwanzleben.....	16.90	84.5
"	"	16.58	85.1
"	"	17.09	89.9
"	Dippe's Kleinwanzleben	15.79	83.1
"	Kleinwanzleben.....	15.96	84.
"	Vilmorin White Improved.....	16.21	87.6
"	" " "	16.52	91.8
"	Dippe's Kleinwanzleben	13.90	81.8
"	Kleinwanzleben.....	16.90	84.5
"	French, Very Rich	14.58	83.3
"	Kleinwanzleben.....	14.86	84.9
"	Dippe's Improved.....	16.11	87.1
"	Kleinwanzleben.....	13.27	78.1
"	"	15.08	83.8
"	Kleinwanzleben Elite	14.39	83.7
"	Knauer's Imperial.....	13.60	82.4
"	Kleinwanzleben.....	14.23	82.2
	Average.....	14.82	83.9
Oct. 13.	.....	15.45	83.5
"	.....	15.85	86.6
"	.....	16.6	95.4

DATE.	VARIETY.	SUCROSE.	PURITY.
Oct. 13.	.....	15.85	86.1
"	.....	15.8	82.7
"	.....	14.95	85.4
"	.....	16.6	86.
"	.....	16.0	84.2
"	.....	15.7	82.2
"	.....	16.35	86.1
"	.....	12.25	79.5
"	.....	12.7	77.4
"	.....	15.1	84.3
"	.....	16.4	85.4
"	.....	14.55	82.2
"	.....	14.6	84.9
"	.....	14.75	86.2
"	.....	14.2	83.5
"	.....	15.55	96.6
"	.....	15.1	86.8
"	Knauer's Imperial, ...	12.8	79.5
"	.....	15.3	84.1
"	.....	15.65	85.9
"	Zuckerreichste, ...	17.25	82.6
"	.....	16.75	85.5
"	Kleinwanzleben Elite, ...	14.65	81.4
"	Kleinwanzleben, ...	13.5	77.
"	Vilmorin White Improved, ...	16.75	82.1
"	.....	14.6	80.2
"	.....	15.15	83.7
	Average.....	15.2	84.2
Dec. 2.	.....	19.2	83.1
"	.....	18.9	87.5
"	.....	18.0	85.7
"	.....	19.2	86.1
"	.....	17.5	85.4
"	.....	18.7	89.
"	.....	16.5	84.6
"	.....	18.5	84.1
"	.....	18.0	82.5
"	.....	15.5	84.7

DATE.	VARIETY.	SUCROSE.	PURITY.
"	....	18.5	84.8
"	....	18.1	84.2
"	....	20.4	89.9
"	....	20.4	88.7
"	....	19.3	86.5
"	....	16.8	80.8
"	....	16.4	82.8
"	....	20.0	85.1
	Average.....	17.7	85.3

The above results show that in many parts of the state the production of sugar beets can be made successful in so far as quality is concerned. The seed was distributed in such quantity as would make it possible to get reliable results as to the yield of roots. Few farmers, however, were able to make the experiment complete, owing largely to the exceptional returns of other crops last year. The reports returned show the yield of beets to vary from six to forty-eight tons per acre. The most reliable estimates place the average yield about twenty tons per acre where the requirements of cultivation were observed. While not as full and complete as it was anticipated the results would be, we can nevertheless say unhesitatingly that all agricultural requirements for the production of good beets are successfully met in Minnesota.

But beyond the necessity of having suitable soil, favorable climatic conditions, unexcelled transportation facilities, we must have what is yet lacking on the part of the farmers, namely: A knowledge of the cultural requirements more generally diffused and a willingness to produce beets. Without a plentiful supply of beets, the best factory, ever so perfect, can only fail.

It is generally known that the manufacture of sugar from sugar beets is, under the provisions of the McKinley bill passed by the last Congress, sufficiently remunerative to induce capital to erect factories wherever good beets in sufficient quantity will be raised.

I am informed the jobbing and confectionery trade of the Twin Cities used last year about 175 tons of sugar per day.

To supply this quantity of sugar would require 25 to 30 factories. As our results have shown we can produce our own sugar.

But the returns from beet raising have not proved satisfactory in many places where factories are now in existence. Inasmuch as it is likely another season may witness the inauguration of the industry in Minnesota it may be well to point out the interdependence of the farmer and manufacturer and the causes which have contributed elsewhere to unsatisfied expectations.

The interest of the farmer and manufacturer are mutual, probably more dependent the one upon the other than in any other industry. A factory costs complete, exclusive of the site, and including ample running capital, nearly a half a million dollars. Such a factory should have 25,000 to 40,000 tons of beets to work into sugar. Inasmuch as the fixed charges including interest, taxes, insurance, etc., must be very large on that amount of investment, and the season for using the beet sugar plant quite short, it is readily seen that inability to secure ample supply of the beets must cause failure. With a bountiful supply of beets any factory could afford to pay higher prices than if the supply were short, so that over-production of beets is not likely to occur. On the manufacturers' side the supply of beets as regards quantity and quality is almost the only question to be solved.

On the farmers' side, however, almost everything remains to be demonstrated. After having proved that good beets can be raised he has yet to demonstrate the yield and cost; but fortunately these conditions are largely controlled by the farmer himself.

The crop, in order to be profitable to the farmer, must show results as follows:

1st. A beet rich in sugar.
2d. A sufficiently large yield per acre.
3d. A not extravagant cost of production.
4th. A sure market at good price.

These requirements can be met by the farmer if he will intelligently and faithfully practice the proper methods of cultivation. These are well determined and no other agricultural

product has had more careful study bestowed upon it, and none is capable of more scientific production.

The four points, enumerated, which it is necessary for the farmer to take into his calculations if he contemplates raising beets, can be settled as follows:

To raise rich sugar beets in good quantity, at the minimum expense the farmer must plant and cultivate them as follows and for the reasons assigned:

1. The seed must be planted thickly, our results show 20 pounds per acre to be best for our conditions, in close rows, say 18 inches apart. By planting thickly a multitude of plants grow from which selection can be made of the most thrifty. Within reasonable limits the more seed planted the less damage can result from poor germination. An acre if shaped forty rods long by four rods wide and using 20 pounds of seed in rows 18 inches apart would require deposited in each row one half pound of seed. That is from three to four times the amount used in seeding for stock beets.

2. The beets must be thinned out early, when they are three to five inches high, and cultivated at that time and frequently thereafter. Direct experiments have repeatedly shown that the amount of sugar in the beets as well as the tonnage yielded is in direct proportion to the amount of cultivation given.

3. The selection of land must be made by reason of its being old and clean, well and deeply plowed and free from manures. If weedy land is used more expense is caused by the greater amount of cultivation needed and it will almost invariably happen that the cultivation must be delayed.

So that by planting thickly, thinning out early and carefully giving frequent cultivation, and making proper selection of soil, the cost of production is minimized, the quality is improved and the yield increased. Furthermore, by this means the maturity of the beet is hastened and made uniform, and the size of single roots decreased and made regular.

Stock beets are usually planted in three feet rows and thin in the rows. In our state phenomenal yields of large

beets are of usual occurrence. A beet for sugar production must not exceed three pounds and is better to weigh only one. When the requirement is stated that beets must be small, one thinks this must decrease the total yield, while on the contrary it increases it. With an acre field forty rods long by four rods wide, there would be forty-four forty rod rows if the same were 18 inches apart. Our soils are so rich that to secure small beets the plants must stand close in the row. If they are let grow four inches apart there would be on one acre 87,120 roots. If each beet weighed but one pound that would represent over forty-three and a half tons. If six inches apart in the rows there could be 58,080 plants, which yielding one pound each would be over 29 tons. If eight inches apart in the rows there could be 43,560 plants, which weighing one pound each would be over 21.75 tons. But to keep the beets from exceeding one pound in our soil it will be necessary to let a great number grow, say one plant every four to six inches, so that the probable yield is large. As high as forty-eight tons per acre were reported last year.

But results worked out on paper always vary from actual experiences and so it has happened with the production of sugar beets. In California the yield has reached as high as sixty-one tons per acre, while in Nebraska the average during the past two years has been under ten tons per acre and as low as three or four tons. An excessive drought was experienced there in 1890 which cut down the yield materially. Except along the western border of our state such droughts do not occur and cannot affect our results. Furthermore the raising of beets in Nebraska has been done mainly upon a large scale by syndicates of business men, not farmers. As beets require a vast amount of work and at certain times, the chances are largely against success when their production is attempted on a large scale; no farmer should attempt to produce more than ten acres of beets and few should raise more than five.

While our results indicate success, farmers should be conservative in raising beets, as the cost of production is much greater than for other crops, and the requirements more exacting.

The premiums offered by the State Fair for the best fifteen samples of beets, where the station should analyze the beets, were to be rated as those having the highest ratio, of both the amount of sugar and the purity of the beets.

This report was submitted to the secretary of the State Fair and has been published by him. It was required that the beets competing for these prizes should reach the Experiment Station not after Nov. 20th. The best beets reaching the Station by that time are as follows, and the prizes have been awarded to the first fifteen samples named:

	Sug. %	Pur. %	Ratio.
O. G. Hoeg, St. Johns, Kandiyohi County	16.1	90.9	190.96
*J. F. Porter, Red Wing, Goodhue County	16.7	85.8	188.75
*P. P. Eddy, Willmar, Kandiyohi County	17.7	80.2	188.23
†H. M. Slee, Dennison, Goodhue County	16.2	86.6	186.80
†J. F. Porter, Red Wing, " "	16.2	85.9	186.03
H. Metz, Randolph, Dakota County	15.2	88.9	183.68
H. Clarke, St. Paul & Duluth Railroad	16.1	83.9	183.26
J. Cappell, Watkins, Meeker County	15.65	85.3	182.26
*H. M. Purdy, Granite Falls, Yellow Medicine County	15.4	84.6	180.08
*P. Klippbein, New Ulm, Brown County	16.4	79.2	179.69
August Lofgrew, Chisago, Chisago County	14.3	88.9	178.59
†P. C. Anderson, Donnelly, Stevens County	15.3	83.6	178.41
R. A. Johnson,	16.1	78.2	176.99
*A. Burkhard, Hay Creek, Goodhue County	15.	83.3	176.39
G. R. Rovel, Sabin, Clay County	14.9	83.7	176.26
H. L. Peuilly, Mazeppa, Goodhue County	14.1	88.7	176.24
P. S. Hasbird, Madison, Lac qui Parle County	14.9	83.2	175.71
J. Sjohleme, N. Branch, Chisago County	13.9	88.3	175.67
A. Kaufer, Montgomery, Le Sueur County	15.8	78.2	175.30
J. Murphy, Barnum, Carlton County	14.8	83.1	175.21
H. Clarke, Sturgeon Lake, Pine County,	15.25	80.9	175.16
W. A. Patten, Le Sueur, Le Sueur County	14.8	88.2	174.05
°J. F. Porter, Red Wing, Goodhue County	14.5	83.3	173.56
††P. Dehew, St. Michaels, Wright County	14.75	81.8	173.31
†A. Kop, Eagle Bend, Todd County	14.	85.4	173.05
P. Weiss, Hutchinson, McLeod County	14.7	81.7	172.93
Jesse Moore, Stacy, Chisago County	13.33	88.7	172.89
J. Hanenstein, New Ulm, Brown County	15.	79.8	172.53
R. A. Peterson, Warren, Marshall County	14.1	84.4	172.51
J. M. Schlehr, Frazee City, Becker County	14.4	82.7	172.34
L. C. Moore,	14.8	80.4	172.06
*J. Peterson, Elbow Lake, Grant County	15.1	78.3	171.45
C. Jobs, Carver, Carver County	14.6	80.7	171.25

	Sug. %	Pur. %	Ratio.
W. Heinecke, Mankato, Blue Earth County	14.5	81.	171.02
J. F. Kahring, Barnum, Carlton County	14.	83.3	170.74
*A. S. Printchers, Ashby, Grant County	14.5	80.6	170.58
C. A. Sargent. Red Wing, Goodhue County	13.6	85.	170.35
Vae Lovack, Kettle River, Pine County	14.1	82.4	170.31
K. B. Norswing, Dennison, Goodhue County	14.5	80.1	170.03
A. Becker, New Ulm, Brown County	14.3	80.8	169.67
F. Griffith, Cokato, Wright County	14.21	81.1	169.59
J. Atkinson, Montana, Carlton County	13.54	84.4	169.35
C. Andrews, Centre City, Chisago County	13.4	85.1	169 33
O. Peterson, Delano, Wright County	13.6	83.4	168.59
H. Lent, Stacy, Chisago County	13.9	81.8	
H. F. Otling, LeSueur, LeSueur County	13.9	81.8	168.51
C. H. Siljan, Madison, Lac qui Parle County	14.	80.9	168.09
C. H. Goodrich, Mankato, Blue Earth County	13.6	82.9	168.04
J. Berg, Rush City, Chisago County	13.9	81.3	167.96
H. L. Penjilly, Mazeppa, Goodhue County	14.	80.5	167.65
B. F. Meetch, Sherburne, Martin County	13.75	81.7	167.55
†D. G. Henring, St. Michaels, Wright County	13.9	80.8	167.41
H. C. Clarke, St. Paul & Duluth Railway	13.8	81.2	167.29
J. F. Hiebel, Alexandria, Douglas County	14.	80.	167.10
W. Wallmarck, Lindstrom, Chisago County	13.6	81.9	166.93
J. Edstrom, Chisago City, Chisago County	13.3	83.1	166.52
W. F. Rigby, Clearwater, Wright County	13.6	81.	165.94
T. Asmundson, Willmar, Kandiyohi County	12.8	84.8	165.61
W. D. Japs, Carver, Carver County	13.7	80.1	165.51
J. D. Buckingham, Glyndon, Clay County	12 6	85.7	165.47
J. Rice, Kennedy, Kittson County	13.3	82.1	
*H. O. Bergh, Berley, Norman County	13.3	82.1	165.42

* Vilmorin White Improved variety.
† Dippes Imperial variety.
○ Kleinwanzleben variety.
†† Bulteau Desprez Richest variety.

The above table gives the analysis of the best sixty samples received up to the 20th of November. Some beets better than these were received after that time, and as late as the 19th of December, when the last lot was analyzed. Beets received since that time have not been analyzed. A number of samples that were shipped previous to that time were received too late for analysis.

COST OF GROWING SUGAR BEETS.

W. M. HAYS.

To determine the cost per ton of raising sugar beets a quantity of seed of the Knauer's Improved variety was planted at the rate of 20 pounds per acre on a rather weedy field that had been manured in 1889 and had subsquently borne two crops, one of corn and one of oats. The seed was planted with a newly invented four-row horse beet seed planter kindly sent us for trial by the Moline, Milburn, Stoddard Co., of Minneapolis. The land after having been plowed eight inches deep was made thoroughly fine by the use of a Tower's pulverizer. The beet seed planter did excellent work although owing to the unusual softness of the seed bed the beet seeds were carried down too far below the general surface by the press drills. The season immediately after planting was unusually wet, preventing cultivation at the proper time and allowing the weeds to get a good start requiring extra expense in weeding. It is, however, to be expected in growing beets that the weeding and thinning will be pretty expensive especially if the weather is rainy at the critical time before the beets are four or five inches high. The plot containing 1⅔ acres was planted in rows 36 rods long and 18 inches apart, and yielded 34,785 pounds of beets or 10.4 tons per acre. One and one-half hours with man and team were required to plant an acre, 72 hours cultivating and 110 hours in harvesting. Calling man and team three hours planting, we have the total labor 184 hours per acre. On a clean field which had borne three good crops of corn and kept very clean of weeds the same variety of beets was planted; the amount of seed, and the method of planting, cultivating etc., were the same as in the weedy plot. This plot contained 32 rows 14 rods long or ¼ acre, and yielded 7,275 pounds of beets or 14½ tons per acre.

One and one-half hours work with man and team was required to plant an acre, 52 hours to cultivate and about the same time as in the other field to harvest. Counting the work of the team equal to the work of a man and one horse as half a team we have the total number of hours expended in planting, cultivating and harvesting the beets on this cleaner land, 171 hours per acre. Counting the rent of the land at $3 per acre, plowing deeply and harrowing $2, the seed 20 cents per pound and the labor $1.25 per day of ten hours we have the cost in the case of the weedy land $30.38 per acre. Reduced to cost per ton of beets we have a greater difference in favor of the clean land. The beets on the weedy land cost $3.25 per ton, while on the cleaner land but $2.09. The latter sum represents the cost of a ton of beets in heaps in the field covered with straw and dirt. To get them to the factory the labor of hauling should be added and would depend greatly upon the distance.

AMOUNT OF SUGAR BEET SEED PER ACRE.

Four plots, each containing eight rows, eighteen inches apart and fourteen rods long, were planted with the Moline, Milburn & Stoddard beet seeder to test different amounts of seed per acre. On planting the first plot on this land, spring plowed eight or nine inches deep, it was found that the press wheels sank down so deep that it was necessary to roll the remainder before planting. The variety used was Kleinwanzleben, planted May 29, 1891. The amount of seed the yield of beets and of sugar, appears as follows:

Plot No.	Pounds of seed per plot.	Pounds of seed per acre.	Yield of beets per plot.	Yield per acre. Tons.
1	13 oz.	12.75	1,345	10.6
2	11 oz.	10.75	1,575	12.7
3	21 oz.	20.50	1,840	14.8
4	24 oz.	23.50	1,895	14.9

The table shows that with this way of planting, twenty pounds are needed, thus confirming the practice of other countries.

DEPTH OF PLANTING.

Three plots were planted to Kleinwanzleben sugar beets to test the depth to run this machine. Twenty and one-half pounds of seed per acre were planted. As mentioned elsewhere all were carried down below the surface too far. Depth here means the distance the seed was planted below the bottom of the press wheel track. These results hardly

Plot No.	Depth Planted	Yield of Beets.	Tons Per Acre.
1	½ inch	830	13.1
2	¾ inch	995	15.6
3	1 inch	850	13.3

apply to depths for planting with garden drills, in which case there is far less pressure on the wheels. The fact that one inch seemed too deep is, however, significant.

The yield in one trial of rows sixteen and eighteen inches apart gave identical results in yields of beets per acre on plots of eight rows each fourteen rods long.

VARIETY TESTS OF SUGAR BEETS.

The table below shows the yields per acre of beets in tons of several varieties, as grown at the Experiment Station in 1891. Those in field A were planted with a two-horse beet planter and those in field B with a Mathews' garden drill, using on all plots twenty pounds of seed per acre, and covering one-half to three-fourths inch deep.

	Source of Seed.	Field A Tons Beets per Acre.	Field B Tons Beets per Acre.
Vilmorin White improved	France.	14.6	
Dippe's Kleinwanzleben	"	16.	
French, Very Rich	"	16.9	
Dippe's Kleinwanzleben	Germany	12.2	
Vilmorin's White Improved	"	12.1	
Dippe's Imperial	"	12.2	
Kleinwanzleben Elite		13.	11.9
Zuckerreichste Elite		14.3	10.4
Vilmorin's White Improved	Utah	13.3	8.8
Dippe's Kleinwanzleben	Utah	15.4	8.5
Knauer's Imperial	Utah	19.5	13.2

All the varieties tried have the habit of growing entirely under the ground on land deeply plowed.

PREPARING SUGAR BEET LAND.

To test a few ways of preparing land for sugar beets several plots were plowed and subsoiled to various depths with results as tabulated below:

	Depth Plowed Inches.	Depth Subsoiled Inches	Yield Per Acre
Plot 1	9		17.6
Plot 2	6		11.2
Plot 3	12		14.2
Plot 4	9	14	13.9

Plowing rich loamy soils to the depth of 8 to 10 inches seems to be the most economical and effective way of plowing land for beets.

The investigations in regard to sugar beets, both as to the possibilities of growing roots rich in sugar and also the economic side of the question, will be continued during the present and following years.

SORGHUM AND SYRUP.

D. N. HARPER.

Over a large portion of the state sorghum is grown and made into syrup. This is used almost entirely in the localities where it is produced, and but little of it finds its way into the general market, so that although the sales are large, the wholesale grocers and the mixing houses in the state are obliged to rely upon other states for a supply of sorghum syrup. One local firm writes that they could sell 1000 barrels of good sorghum syrup yearly if they could get the goods, but the supply does not equal the demand and the quality is too variable. The wide production of sorghum and the large demand for the syrup, together with the absence of any data upon the quality of the cane, its cost of production etc., led me to make certain investigations during the years 1889 and 1890. By these I hoped to secure reliable information, (1) as to the methods of cultivation, (2) the yield and cost of production, (3) the quality of the cane, (4) the methods and cost of manufacture and (5) the quality of the product. But I have found it possible to get such information only upon the quality of the cane and its products and the methods of manufacture. Cultivation is not specially directed to the production of a sugar crop and the methods are in general the same as those for corn. There is no special selection of the plot and no measurement of its size, no record taken of the yield etc. It is therefore impossible to closely estimate the cost of the crop and the profits arising from it. The most reliable estimates show that the syrup costs from 20 to 35 cents per gallon. This has ready sale at home at from 50 to 60 cents per gallon, or saves an outlay for other syrups costing from 60 to 80 cents. The quality of the syrup is quite variable and depends as well upon the character of the cane and the manner of handling it as upon the methods of manufacture. The charge for manufacture at Cannon Falls and Red Wing is 15 cents per gallon and

this yields a reasonable profit; but the actual cost of manufacture varies with the cane. That which has been grown upon suitable land, after the proper manner and harvested and handled carefully yields a good syrup, the largest quantity with the least expense, but some lots of cane at the charge of 15 cents, as stated, are manufactured at a loss.

The quality of the cane is more important to us, and last year this called for our chief attention. For the last season's work I arranged a temporary laboratory in the factory of Mr. J. F. Porter, at Red Wing, and kept chemical control over the manufacture of the syrup and from time to time made analyses of canes selected from Mr. Porter's fields. Four different varieties of cane had been grown, namely: Early Orange, Folger's Early, Early Amber and Kenney's Early Amber. The seed of the first two varieties was received from the U. S. Department of Agriculture, and was the seed-heads of selected canes grown during the previous year, at Sterling, Kansas. The Early Amber seed was native grown and Kenney's Early Amber seed was obtained from Hon. S. H. Kenney, of Morristown, Minn. It is a variation of Early Amber which originated with him. The Early Orange grew on rather the heaviest land and produced the largest stalks, but was quite green when frost killed it on September 27th. Folger's Early grew on black sandy loam produced large stalks and was within a week of being ripe when frost occurred. The Early Amber grew upon moderately light sandy loam at an elevation considerably above the other plots. The stalks were tall and slender and would have ripened within a few days when frost killed it on the 27th of September. Kenney's Early was grown upon the lightest soil and produced short, heavy stalks, none exceeding a height of six feet. It ripened about the 23d of September.

The canes from the selected Kansas seed produced very few suckers, but those from domestic seed suckered badly. All the seed was planted in rows 3½ feet apart and about 12 inches in the rows. Owing to the season the cultivation given was defective.

In the following tables I give the results of the analyses of selected canes and for purpose of comparison the results obtained at *Sterling and †Fort Scott, Kansas, two places considered especially favorable to the production of sorghum.

In making comparison it must be borne in mind that the seed which produced the canes analyzed in Kansas had been especially selected according to scientific principles during three years previous, while the Early Amber seed with us had not been previously selected in any way.

To show how intelligent selection had affected their crop, I quote the record of results at Sterling, Kansas. The seed for the crop of 1888 was from canes, the seeds for which had not been previously specially selected, but the crops of 1889 and 1890 were from selected seed:

*FOLGER'S EARLY.

	Solids.	Sucrose.	Glucose.	Purity.
1888	15.62	10.66	1.88	68.24
1889	18.39	14.08	2.03	76.56
1890	18.85	14.28	1.19	76.89

EARLY AMBER.

	Solids.	Sucrose.	Glucose.	Purity.
1888	15.00	9.50	2.35	63.34
1889	15.81	11.69	1.25	73.94
1890*	18.08	12.84	1.50	71.02

*Unselected.

These results show the gradual and presistant improvement in the cane by the selection of the seed. But the seed for the Early Amber crop of 1890 was not specially selected and its improvement did not keep pace with that of Folger's Early where seed selection had continued.

*Dr. Wiley's Report for 1890. Bulletin.

†29, Division of Chemestry, U. S. Department of Agriculture.

EARLY AMBER.

Date.	Lab'y No.	Solids.	Sucrose.	Reducing Sugars.	N-10 Alkali	Purity.
		Per cent.	Per cent.	Per cent.		Per cent.
September 15 ..	1204	15.20	9.21	3.14		60.59
" 16...	1220	14.70	9.20			62.58
" 17...	1236	18.40	11.81	2.27	.7	64.18
" 22...	1286	17.65	12.61	2.52	1.2	71.44
" 22...	1287	16.96	12.49	2.25	1.4	73.64
" 22...	1288	16.88	12.80	2.40	1.8	75.83
" 22...	1294	18.55	13.93	2.16		75.09
" 24...	1310	20.70	15.28	2.92		73.81
" 24...	1311	19.25	14.04	2.44	1.6	72.93
" 24...	1312	15.98	10.74	1.81	1.6	67.20
" 24...	1313	18.00	13.35	1.88	1.7	74.17
" 24...	1314	16.90	12.31	1.70	1.9	72.84
" 24...	1316	15.50	9.51	3.03	.9	61.35
" 24...	1317	13.78	7.47	4.12	.7	54.20
" 24...	1318	17.33	11.11	2.87	.8	64.10
October 1...	1318½	17.14	12.03	4.67	1.7	70.18
" 24...	1319	14.98	8.50	3.05	1.0	58.70
" 24...	1321	16.42	11.60	2.57	1.1	70.64
" 26...	1336	18.98	15.11	2.44	1.5	79.08
" 26...	1337	20.22	14.61	2.75	1.3	72.25
" 26...	1338	15.20	9.36	2.69	1.7	61.57
" 26...	1339	19.88	15.06	1.76	2.2	75.75
" 26...	1340	19.82	14.22	2.49	1.5	71·74
" 26...	1341	20.32	15.33	1.88	1.8	75.44
" 27...	1356	16.60	11.29	2.64	1.5	68.01
" 27...	1357	17.92	12.14	2.91	1.3	67.80
" 27...	1358	17.85	12.27	2·27	2.0	68.74
" 27...	1359	16.30	11.00	2.93	1.2	67.24
" 27...	1361	18.55	11.63	2.95	1.4	62.69
" 27...	1364	18.40	12.42	2.38	2.6	67.60
" 29...	1369	15.56	10.42	2.61	1.4	66.96
" 1...	1385	15.62	10.42	2.44	2.0	66.71
" 1...	1386	13.58	8.34	2.37	1.0	61.41
" 1...	1387	17.38	12.87	1.94	2.5	73.88
" 1...	1388	16.45	11.66	2.34	2.2	70.28
" 2...	1392	16.32	10.88	2.08	1.6	66.66
" 2...	1393	15.54	9.99	2.41	1.5	64.29
" 2...	1394	15.60	10.42	2.61	1.6	66.79
" 2...	1396	15.68	11.33	1.91	2.5	72.26
" 2...	1397	16.78	11.59	2.17	1.6	69.07

AVERAGES.

Date.	Lab'y No.	Solids.	Sucrose.	Reduc'g Sugar.	N-10 Alkali.	Purity.	Solids Not Sugar.
Sept. 5 to Oct. 2		17.01	11.76	2.42		66.99	
" 22 to Sept. 26		17.62	11.49	2.60		70.10	
Greatest.....		20.70	15.33	3.13		79.08	
Least.....		13.58	8.34	1.70		54.20	

AT STERLING, KANSAS.

Average		18.08	12.84	1.50		70.02	3.74

AT FORT SCOTT, KANSAS.

Average		17.3	13.2			76.3	
Greatest		18.5	14.1			80.6	
Least.....		16.0	11.7			71.0	

KENNEY'S EARLY.

Date.	Lab'y No.	Solids.	Sucrose.	Reducing Sugar.	Purity.	Solids not Sugar.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
September 22	1290	17 7	13.67	2.05	77.23	1.98
" 22	1291	18.42	14.09	1.78	76.49	2.55
" 22	1292	17.63	12.76	1.83	72.38	
" 22	1293	16.55	12.52	1.33	75.74	
" 24	1205	17.75	12.18	1.89	68.62	
" 24	1306	15.60	9.92	2.47	63.59	
" 24	1307	19.05	13.39	1.33	70.28	
" 24	1308	18.80	13.46	2.29	71.59	
" 24	1309	19.16	14.02	1.71	73.17	
" 26	1346	18.38	12.73	2.73	69.26	
Average.....		17.90	12.87	1.94	71.84	
Greatest..... ...		19.16	14.09	2.73	77.23	
Least.....		15.06	9.22	1.33	63.59	

FOLGER'S EARLY.

September 16	1222	14.24	7.64		53.65	
" 16	1223	17.00	13.25		77.94	
" 27	1351	19.38	12.68	2.37	65.42	
" 27	1352	18.15	11.22	2.91	61.81	
" 27	1353	18.38	11.72	3.10	63.76	
" 26	1354	18.58	12.84	2.41	69.09	
Average.....		15.95	11.52	2.69	65.28	
Greatest..... ...		19.38	13.25	3.1	77.94	
Least.....		14.24	7.64	2.37	53.65	

AT FORT SCOTT, KANSAS.

Average.....		18.40	13.5		73.40	
Greatest..... ...		19.40	15.6		80.40	
Least.....		15.80	10.7		67.70	

AT STERLING, KANSAS.

Average..		18.85	14.12	1.76	74.69	2.97

Our analyses show that we produced sorghum the quality of which compares favorably with that produced in the localities considered naturally better adapted to sorghum. From seed which had never been specially selected we produced Early Amber of nearly as high average quality as that produced in Kansas from selected seed and the best of our cane was better than the best of theirs. In Kansas the production of sorghum is for the manufacture of sugar but with us it must be confined to the manufacture of syrup, with the production of sugar incidental. The manufacture of sugar from the sorghum has not yet proved entirely suc-

cessful anywhere and it will not be profitable for us to endeavor to make it prove so here. In addition to the causes which have operated infavorably elsewhere, our short season for working up the cane has been considered fatal to sugar manufacture here, but our results seem to indicate that this feature may not be a fault. Hard frosts occurred on the 27th, 28th and 29th days of September before any of Mr. Porter's cane had been cut. On the 29th the Early Amber was stripped and harvested and made into an excellent syrup. To study the effects of frost upon standing cane some rows were not cut down at all and analyses were made of sample canes from day to day. The averages of the daily analyses are arranged in the followeng tables:

EARLY AMBER.

BEFORE FROST.

Date.	Solid. Per cent.	Sucrose. Per cent.	Glucose. Per cent.	Purity. Per cent.	N-10 Alkali. c. c.	Solids not Sugar. Per cent.
September 22	17.51	12.98	2.33	74.00	1.5	2.20
Ratio.....	7.5	5.6	1.			
September 24	18.17	13.14	2.15	74.19	1.6	2.88
Ratio.....	8.5	6.1	1.			
September 26	18.80	13.49	2.21	71.13	1.9	3.10
Ratio.....	8.5	6.1	1.			

AFTER FROST.

September 27	17.51	11.70	2.77	64.83	1.5	3.04
Ratio.....	6.3	4.2	1.			
September 29	15.56	10.42	2.61	66.96	1.4	2.53*
Ratio.....	6.	4.	1			
October 1	17.42	12.27	2.14	72.08	2.3	3.01
Ratio.....	8.	5.7	1.			
October 2	16.23	11.46	2.04	70.66	2.	2.73
Ratio.....	8.	5.6	1.			
October 4	14.30		1.99			
Ratio.....	7.2		1.			
October 10	12.04		2.34		1.2	
Ratio.....	5.1		1.			

*One cane.

Naturally a general decrease in the density of the juice occurred after frost, but that there was so little inversion of the cane sugar seemed quite remarkable. This may be explained from the fact that the temperature did not at any time after frost rise sufficiently high to permit of much fermentation.

By a comparison of the daily maximum temperatures after frosts for the past few years it is seen that this low temperature is not unusual. Through the kindness of Prof. O. Whiteman I have arranged the following table of maximum temperatures observed by him at Red Wing during the past six years:

Date.	1885	1886	1887	1888	1889	1890	1885	1886	1887	1888	1889	1890
September 18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	35.6	.....
" 19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
" 20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
" 21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
" 22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
" 23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
" 24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
" 25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
" 26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	33.2	.....
" 27	.....	.....	.....	.....	4.55	.....	.....	.....	.....	.....	32.1	36.
" 28	.....	.....	.....	.....	65.	.....	.....	.....	.....	.....	.....	32.2
" 29	.....	.....	.....	.....	67.2	49.4	.....	.....	.....	28.2	.....	.....
" 30	.....	.....	.....	71.3	60.	55.2	.....	.....	.....	.....	.....	.....
October 1	.....	.....	.....	.....	69.5	58.	.....	31.4	.....	.....	.....	.....
" 2	.....	63.3	.....	.....	48.9	57.3	.....	32.	.....	.....	.....	.....
" 3	.....	70.9	.....	.....	66.	58.6	.....	.....	.....	.....	.....	.....
" 4	.....	67.9	.....	.....	56.9	63.5	26.3	.....	34.9	.....	.....	.....
" 5	42.8	71.4	59.1	.....	63:	53.9	26.6	.....	34.	.....	.....	.....
" 6	50.1	72.2	64.	.....	43.6	51.8	31.8	.....	.....	.....	.....	.....
" 7	52.8	77.5	68.9	.....	41.	55.6	.....	.....	.....	.....	.....	.....
" 8	51.2	77.	72.	.....	48.	54.5	31.	.....	.....	.....	.....	.....
" 9	68.	73.	53.1	.....	59.	59.4	.....	.....	.....	.....	.....	.....
" 10	76.	75.5	48.4	.....	50.	53.	.....	.....	.....	.....	.....	.....
" 11	69.	75.5	46.	.....	61.8	51.5	.....	.....	.....	.....	.....	.....
" 12	58.9	67.7	59.	.....	66.2	50.2	.....	.....	.....	.....	.....	.....
" 13	53.1	76.	49.3	.....	52.	62.	.....	.....	.....	.....	.....	.....

Frost has not appeared to cause much injury to ripe cane in the vicinity of Red Wing, but no analyses have hitherto been made to show its effects. Many farmers have a practice of cutting their cane before it is ripe to save it from being frosted. In this way cane was cut last year while still quite unripe, as much as two weeks before frost occurred. As the greatest improvement in the quality of the cane occurs during the short period of ripening, a great loss is sustained by harvesting it while green.

Our results would show that the proper practice is to allow the cane to grow until it matures and not cut it while yet unripe in apprehension of frost. If, however, frost should occur, let it be cut, tied in small bundles, and piled in the shade in such a way that air can have free circulation throughout the piles. It should then be made up into syrup as quickly as possible. That this was the proper practice last year was shown by the results of Mr. Porter's own cane and lots from other parties. The best canes received last Fall were those which came in last and they made the best syrup, while the canes which were harvested while green made poor syrup and that with great difficulty.

STRIPPING CANE.

Many farmers have concurred that some improvement occurs by allowing cane to stand after being stripped, but such treatment really injures it. Cane should be harvested as soon as it is stripped and made into syrup immediately afterwards. Through a misunderstanding a number of rows of Mr. Porter's Early Amber were stripped on the 24th of September. To learn how this cane would compare with that not stripped, analyses were made of similar canes of both kinds. The average result of daily analyses of stripped cane follow, for comparison with canes not stripped refer to to the table on page 104.

STRIPPED CANES.

BEFORE FROST.

Date	Solids Per cent.	Sucrose Per cent.	Glucose. Per cent	Purity. Per cent.	N-10 Alkali c. c.	Solids not Sugar. Per cent.
September 24	15.94	10.03	3.67	62.46		2.24
Ratio.....	4.3	3.8	1.			
September 26	19.60	14.86	2.58	75.67	1.4	2.16
Ratio.....	7.6	5.7	1.			

AFTER FROST.

September 27	18.4	12.42	2 38	67.60	2.6	3.60*
Ratio.....	7.8	4.4	1.			
October 1	14.60	9.38	2.40	64.06	1.5	2.82
Ratio.....	6.	3.9	1.			
October 2	15.82	10.10	2.33	65.91	1.6	3.39
Ratio.....	6.8	4.3	1.			
October 4	13.54		2.88			
Ratio.....	4.7		1.			
October 10	13.87		3.23			
Ratio.....	4.3		1.			

*One cane.

More glucose, less sucrose and lower purity resulted in the stripped canes and frost caused more damage to them than canes in their natural condition. But the effects of stripping cane were quite marked in the working of it in the factory. Cane which had been stripped was much more difficult to work up than the other, and this showed itself particularly in the evaporation of the juice to syrup. So that for all reasons it proved to be a wrong practice to let stripped cane stand.

RIPE STALKS AND SUCKERS.

Last season was very peculiar and one not favorable to the development of a sugar producing crop. Drought during the early part of the summer prematurely advanced the cane and a subsequent excess of moisture prevented perfect maturity and favored the growth of suckers. The great majority of the Early Amber canes had from one to six suckers, which, owing to the season, ripened but little later than the main stalk. Analyses of individual stalks and suckers growing from these showed there was not so great a difference in them as ordinarily. Analyses were made of other canes having no suckers and the results are compared in the following table:

	Solids. Per cent.	Sucrose. Per cent.	Glucose. Per cent.	Purity. Per cent.	Solids not Sugar Per cent.
Main Stalks	14.48	8.50	3.05	58.70	2.93
Suckers of same	13.78	7.10	3.94	51.52	2.74
Main stalk	16.42	11.60	2.57	70.64	2.25
Suckers of the same	18.02	12.62		70.03	
Main stalk	15.60	10.42	2.61	66.79	2.57
Suckers of same	14.00	7.71	2.96	55.07	3.33
Stalk. No suckers	20.22	14.61	2.75	72.25	2.86
" " " "	20.32	15.33	1.88	75.44	3.11

Few canes grew without suckers but when they did grow so they matured earliest and all analyses showed them to be the best. From conversation with many farmers I learned that the opinion prevails that canes with suckers are as good if not better than those not producing suckers, so that of course but few farmers suckered their cane.

All investigations upon this matter hitherto have shown that canes with suckers do not ripen uniformly nor as early as canes without suckers, and the quality of canes with

suckers is not as good. Our analyses gave the same results. Therefore instead of encouraging or permitting the growth of suckers they should be prevented.

VARIABILITY OF THE CANE.

Besides the analyses already recorded others were made of the cane of various farmers. They show the greatest variation in the composition of the juice and are quoted further on. This extreme veriability of sorghum has been noticed everywhere. If it is hoped to make sorghum uniform in its quality and growth, care must be exercised first of all in selection of seed. With us this selection should be made early to secure (1) early ripening cane and (2) cane of high quality.

All experience shows that Early Amber is best adapted to our conditions and selections should be made from this variety. The earliest ripening canes which are of the highest quality can be secured best with the aid of analyses of the canes, but at Attica, Kansas, last year it was observed that certain exterial appearances indicate quite closely the ripeness and quality of individual canes. This is reported as follows:

*"Special attention was given to studying the characteristics of the cane, showing that certain physical properties are associated with high percentage of sugar. By studying these properties carefully, it is possible for every farmer to go into his field and be able to determine with certainty whether his cane is ripe or not. The most striking of these properties is found in the last joint of the cane bearing the seed head. By stripping the cane of its covering a yellow coloration will be observed extending more or less along the length of the joint as the cane nears maturity. By the extent of this coloration one is able to select the very best or the very poorest canes in the field almost as accurately as though tested by a polariscope. *It is found that the cane which has the highest sucrose, lowest glucose, and highest purity has coloration extending one-half the length of the joint.* Should it be found to extend the full length it

*Bulletin No. 29 Division of Chemestry, U. S. Department of Agriculture, 1890 page 24.

shows the cane has already commenced to deteriorate. On the other hand should no coloration be visible it shows that the cane is not yet matured. These observations have extended over one season of rather remarkable charicteristics and hence they may not prove equally applicable to a crop grown in a season with the ordinary rainfall."

It has been observed as regards quality and ripeness that as a rule those canes having the smallest seed heads are of the best quality and reach maturity when the seed grains become hard and glistening. In the case of Early Amber the seed becomes black.

In selecting seed therefore choose canes which are free from suckers, ripen earliest, have the smallest seed heads and show by the coloration of the seed-head joint that they contain the most sugar and highest purity.

For the successful manufacture of syrup, to which we confine ourselves, it is as necessary to have good cane as for the manufacture of sugar.

As a commencement in the improvement of the Early Amber cane the seed of those canes which were the best last year have been planted this spring and selections of the canes for seed will be continued.

For the improvement of the cane it is necessary that better methods of cultivation should be obtained; but very little has been accomplished in this direction and it will not be necessary to discuss any methods of cultivation at present.

THE MANUFACTURE OF SYRUP.

During a few days at the end of the season of 1889 at Cannon Falls, I kept chemical control of the operations in the manufacture of syrup. Analyses were made (1) of the juice as it came from the mill, (2) after defecation, and as it enters the evaporator, (3) of the juice after it had passed one-fourth, one-half and three-fourths of the evaporator and (4) of the finished syrups.

The analyses showed great differences in the quality of the cane and of the syrup. Special attention was paid to the defecation of the juice and the working of the evaporator.

Defecation was not properly conducted but this was promptly corrected.

Many analyses showed that no inversion of the sugar occured during the process of evaporation to syrup; the evaperator works well and with great rapidity. The records of three analyses were consumed with the Experiment Station building so that only a general statement of the results can be given.

In 1890 the investigation was continued in the factory of J. F. Porter, at Red Wing, but special attention was given to the cane itself. The results of the seasons work show that the chief cause for the variability of sorghum syrup is in the variable character of the cane. While not perfect, the mechanical features in the production of sorghum syrup, are far in advance of the agricultural ones. Improvement needs to be made in the nectary of the cane to secure a greater yield of the juice, in the defecation and filtering of the juice to make the quality of the syrup more uniform. But uniformity of the syrup now depends chiefly upon the character of the cane, its cultivation and subsequent treatment before arriving at the factory.

To show the variable character of the cane I quote the average results of the analyses of forty-four lots of cane raised by as many different farmers and the analyses of the best and poorest lots. This wide difference in the cane must be corrected before unifority of syrup can be obtained. Some of the means to secure uniformly good cane have been suggested.

MILL JUICES.

	Solids. Per cent.	Sucrose. Per cent.	Glucose. Per cent.	Purity. Per cent.	Solids not Sugar. Per cent.	Lab'y No.
Average.....	15.10	8.52	8.74	56.54	2.84	
Best canes.....	15.86	10.87	2.38	68.53	2.61	12301
	16.00	10.62	2.72	66.37	2.66	1269
	15.68	10.53	2.46	67.15	2.69	1390
	15.42	10.51	2.73	68.15	2.18	1378
	17.15	11.93		68.48		1208
	14.70	10.77		73.26		1207
Poorest canes.....	16.22	4.05	6.95	24.97	5.22	1323
	15.40	6.19	5.25	40.19	3.96	1325
	16.48	7.17	3.90	43.50	5.41	1266
	9.25	4.84	4.10	52.32	.31	1398

The large amount of glucose in these canes is due partly to the unripe condition of the cane and partly to the cane having for some time stood in piles in such a way that fermentation and inversion occurred. When cane stands after being cut the piles should be made so that the air can have access and thus keep the temperature low. If the cane is kept at a temperature below 68° Fahrenheit so fermentation will take place. But for all reasons cane should stand as short a time as possible after being cut.

It was found necessary several times to leave the juice stand over night before being defecated. To learn what effect this might have upon the sugar some analyses were made the results of which follow:

	Sucrose. Per cent.	Glucose. Per cent.	Increase of Glucose.
No. 1288.	12.80	2.40	
After standing exposed 36 hours	12.19	2.59	.19
No. 1290.	13.67	2.05	
After 36 hours		2.09	.04
No. 1292.	12.76	1.83	
After 36 hours		1.92	.09
No. 1294.	13.93	2.16	
After 36 hours		2.22	.06
No. 1309.	13.02	1.71	
After 48 hours	13.80	2.64	.93
No. 1311.	14.04	2.44	
After 48 hours	13.99	2.44	
No. 1313.	13.35	1.88	
After 48 hours		3.58	1.70
Average increase of glucose after 36 hours		.095	
After 48 hours		.88	

These results showed that the juice suffered no injury by standing over night. It was therefore subsequently the practice to have the tanks full of juice in the morning. This saved a great deal of time in the morning following. But frequently it was necessary to run both day and night.

The fact that no appreciable inversion took place on allowing juice to stand exposed for 36 hours is of special importance to us should sugar production be undertaken. A large part of the loss in sugar making in more southern states results from the inversion of the cane sugar after the juice has been secured and during the process of manufacture. No such loss occurs with us. But for syrup production it is not especially important since the crystalization of sugar is not desired.

University of Minnesota.

Agricultural Experiment Station.

BULLETIN No. 22.

AUGUST, 1892.

I.—COMPARISON OF CORN; BARLEY; CORN AND SHORTS; BARLEY AND SHORTS; CORN, SHORTS AND OATMEAL; AND BARLEY, SHORTS AND OIL MEAL IN THE RATION OF GROWING PIGS.

II.—CORN VS. BARLEY FOR FATTENING HOGS. III.—CORN MEAL, BARLEY MEAL AND A MIXTURE OF BARLEY MEAL AND OIL MEAL COMPARED.

IV.—WET VS. DRY FEED.

☞ The Bulletins of this Station are mailed free to all residents of the State who make application for them.

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CORN VS. BARLEY.

CLINTON D. SMITH.

While the popular taste demanded a heavy and excessively fat hog to bring the highest price in the general market, profitable pork production on a large scale was confined to those states in which was found the peculiar combination of soil and climate best adapted to corn growing. Corn stands easily at the head of onr American cereals for fattening swine, but it has not yet been shown that its superiority extends to the feeding of young or growing pigs. In England and on the continent of Europe barley occupies a relation to swine production similar in some respects to the place occupied by corn in America, and Sir John B. Lawes has gone so far as to say that barley is the natural food of the civilized pig.

The late frosts of spring and the early ones of autumn make corn an exceedingly precarious crop in all the northern parts of this state while barley is at its best in those latitudes. To study the question, therefore, whether barley could be substituted for corn in the ration of pigs, experiments were undertaken during the summer of 1891.

Thirty-four pigs as nearly alike as possible were selected from the farm herd on the 21st of July and divided into six groups, two of five pigs each, called pens 9 and 10, and four of six pigs each, called pens 11, 12, 13 and 14. Due care was taken to have the pigs in each pen mated in all respects with the pigs in every other pen so that the results of the feeding test with all the pens are comparable. The average weight of the pigs was then 42 pounds. After a preliminary feeding period of one week, during which each pen received the food which was to constitute its ration during the entire experiment, each pig was again weighed on two successive days and the average of these two weights was taken as the original

weight in the computation of results. Each pig was weighed weekly at the same hour of the day during the progress of the experiment. The amount of food consumed by each pen each week of the experiment was also carefully weighed.

During the entire trial the groups of pigs were confined to small pens with exercise yards adjacent, were supplied with an abundance of fresh water and were allowed all the charcoal, ashes and salt they would eat. The feed was mixed with sufficient water to make a thick slop and the clean drinking water was given them in a separate trough. During the preliminary feeding and for one week afterwards each pen was allowed one pound per pig per day of green pea forage. The ration of pen 9 with this exception consisted of corn meal alone; that of pen 10, of barley meal. Pen 11 had corn meal and shorts mixed in equal proportions by weight. Pen 12 had barley meal and shorts mixed in equal proportions. Pen 13 had corn, shorts and oil meal mixed in the proportion of two parts corn meal, two parts shorts and one part oil meal. Pen 14 received a ration consisting of two parts barley meal, two parts shorts and one part oil meal.

A summary of the results of the first feeding period of five weeks is given in the following table:

TABLE I.

PERIOD I.—FIVE WEEKS.

Pens—	9	10	11	12	13	14
	Corn.....	Barley.....	Corn ½ and shorts ½...	Barley ½ and shorts ½....	2-5 corn, 2-5 shorts, 1-5 oil meal.....	2-5 bar., 2-5 shorts, 1-5 oil meal.....
Average weight July 28	52.6	51.4	51.	48.7	54.5	47.3
" " Sep. 2	71.	75,2	84.7	82.	89.3	81.3
Average gain, five weeks	18.4	23.8	33.7	33.3	34.8	34.
Total weight July 28	263.	257.	306.	292.	327.	284.
" " Sep. 2	355.	376.	508.	492.	536.	488.
Total gain	92.	119.	202.	200.	209.	204.
Food consumed	513.5	554.	811.5	762.	771.	728.
Lbs. gain for each 100 of feed	17.9	21.4	24.9	26.2	27.1	28.

At the close of the first period there was a very noticeable difference in the appearance of the pigs of the various pens.

Those in pen 9, fed exclusively on corn meal, had developed a strong tendency to lay on fat rather than make a normal growth of bone and muscle. The pigs were short, inclined to be pot-bellied, were all of them overly fat, deficient in vitality and in every way gave evidence of the lack of bone and muscle producing materials in their diet. The experience of practical feeders and a multitude of trials at experiment stations have demonstrated that corn meal alone does not contain all the elements necessary to make a healthy growth in the young of our domestic animals. If the attempt is made to feed young pigs just weaned, on corn meal either alone or as the chief article of diet the bowels will be found either constipated or too loose, the appetite will be irregular and the growth unsatisfactory, there being too great a tendency to become fat and too small a development of the bones and muscular system. The results of this experiment point to the same conclusion.

The pigs fed on barley alone did not show this unfortunate tendency to so great an extent. They were more active, more muscular, longer bodied and had not the potty appearance of the pigs in pen 9. The other four pens, although showing to some extent the deleterious effects of too close confinement at that hot season of the year, had none of this tendency to the laying on of too much fat but throughout the experiment were lively, vigorous and thrifty.

The average gain per pig in the lot fed barley alone, pen 10, was 23.8 lbs. for the five weeks, while in the case of the corn fed lot it was but 18.4 lbs., a difference of 5.4 lbs. of gain per pig in favor of the barley. The addition of shorts to both corn and barley had the effect of increasing the gain very noticeably. The average gain per pig in each of the lots fed a mixed diet was almost identical, namely 33.7 lbs. and 33.3 lbs. where shorts alone was added, and 34.8 lbs. and 34 lbs. where oil meal formed a fifth part of the ration.

One hundred pounds of corn meal fed to the small pigs in pen 9 produced but 17.9 lbs. of gain but where, as with pen 11, one half of the corn meal is replaced by shorts one hundred pounds of this mixture produced 24.9 lbs. of gain, a difference of 7 lbs. in favor of the mixed diet. Where one-fifth

of the ration otherwise composed of equal parts of corn and shorts consists of oil meal the gain per hundred pounds of the mixture consumed was 27.1 lbs. or 2.2 lbs. of gain in excess of that of corn and shorts and 9.2 lbs. more gain for each hundred pounds of the mixture than was produced from a hundred pounds of corn meal alone.

Where barley formed the basis of the ration the advantages of adding shorts or shorts and oil meal to the single grain feed are not so apparent. One hundred pounds of barley meal gave in pen 10 a gain of 21.4 lbs., one hundred pounds of barley and shorts in pen 12 a gain of 26.2 lbs. and barley and shorts with a fifth part of oil meal gave in pen 14 a gain of 28 lbs. per hundred pounds of feed consumed.

Comparing now barley either alone or mixed with other feeds with corn in the same situation it is to be noted that while the gain in pen 10 fed exclusively on barley was in the proportion of 21.4 lbs, for each hundred pounds of barley consumed, that of pen 9 fed on corn meal was 17.9 lbs. of gain for each hundred pounds of food consumed, a difference of 3.5 lbs. of gain per hundred of feed in favor of barley. Where shorts was fed with the barley and corn there is a difference of but 1.3 lbs. of gain per hundred weight of feed consumed in favor of barley and where oil meal was added in the proportions indicated this difference is reduced to .9 of a pound.

Two points are thus clearly indicated by the results of this period of the experiment. To make rapid growth with young pigs a mixed diet is essential. This mixture or variety of foods may be obtained either by turning the young pigs out to pasture or if confinement is necessary by feeding more than one kind of grain. The addition of oil meal seemed to slightly increase the total gain during this early period of their growth and gave the pigs a glossiness of coat and general air of thriftiness not possessed by the other pens. These increased gains made by the pigs having a mixed diet were put on with a noticeably less proportion of food consumption. This was undoubtedly due largely to the fact that these pigs had a better appetite and consumed a greater amount of food than the pigs having the corn or barley alone. For,

since a certain amount of food must be consumed in maintaining the life of the animal, supporting the vital functions and replacing the tissues necessarily worn out, the more an animal can be induced to eat and digest the greater will be the surplus available for building up new tissues or laying on fat.

In this experiment barley seems to have been more valuable pound for pound than corn in growing these young pigs. Fed alone one hundred pounds of barley produced 3.5 lbs. more of gain than one hundred pounds of corn, and even when mixed with either shorts alone or shorts and oil meal a slight advantage seems to lie on the side of barley.

PERIOD II.

In the following table is given for the second period of five weeks statistics similar to those recorded in table one for the first period.

TABLE II.

PERIOD II.—FIVE WEEKS.

Pens—	9	10	11	12	13	14
	Corn.....	Barley.....	Corn and shorts.....	Barley and shorts.....	2-5 corn, 2-5 shorts, 1-5 oil meal....	2-5 barley, 2-5 shorts, 1-5 oil meal
Average weight September 2	71.	75.2	84.7	82.	89.3	81.3
" " October 7	85.4	112.4	125.8	122.5	129.3	119.3
Average gain	14.4	37.2	41.1	40.5	40.	38.
Total weight September 2	355.	376.	508.	492.	536.	488.
" " October 7	437.	562.	755.	735.	776.	716.
Total gain	82.	186.	247.	243.	240.	228.
Food consumed	538.	872.	1131.	1062.	1158.	1080.
Lbs. gain for each 100 lbs. of feed	15.2	21.3	21.8	22.8	20.7	22.

A comparison of the two tables shows that with the single exception of pen 9 each pen shows a greater average gain per pig and a greater aggregate gain in the second period than in the first. In the case of pen 9 the appetite of the pigs owing to the confinement of the diet to the single very imperfect food, Indian corn, was very irregular and the gain was unsatisfactory. With barley on the other hand the appetite was noticeably better and the average gain nearly as great as in the pens which received a mixed diet. The

superiority of barley over corn as a food for young pigs is evidenced by the behavior of these two pens, 9 and 10, in both feeding periods.

As in the former period, when mixed with shorts, barley seems to be more effective with these pigs than corn in a similar mixture. As was to be expected, since older animals are never able to show as great gain in proportion to food consumed as younger ones, the gain for each hundred pounds of feed is less with each pen in this period than in the former one, but here also the advantage lies with the barley. Pen 10 showed in the second period a gain of 21.3 lbs. for each hundred pounds of food consumed, in period one a gain of 21.4 lbs. for each hundred pounds of barley, the decrease for this pen being less than for any other.

When fed as the exclusive feed, one hundred pounds of barley produced 6.1 lbs. more gain than one hundred pounds of corn; when mixed with shorts one hundred pounds of the mixture gave a gain greater by one pound than corn and shorts and when oil meal was added to each mixture the difference in gain in favor of barley was 1.3 lbs. The pens 11 and 13, however, in both periods made a slightly larger gain than did pens 12 and 14 but consumed also more feed. The addition of oil meal to the ration, seemed in this period to lessen rather than increase its effectiveness. The total gains were slightly less with the pigs to which the oil meal was given and the amount consumed was slightly greater. As the average weight of the pigs was at this time not far from 100 pounds the indications of this one experiment are that oil meal is more valuable with pigs under this weight than with larger ones. Oil meal is a food for which pigs have not the craving which is essential to make its use in fattening swine profitable.

The appetite of the pigs in pen 9 was very irregular and they could be induced to eat but little more than enough to sustain life, notwithstanding the fact that they had condimental food, ashes, charcoal and salt, in abundance. Where however, the corn is mixed with shorts or with shorts and oil meal the pigs ate considerably more of it than they did of similar mixtures of barley. They made correspondingly

larger gains and at no greater proportional expense of food consumption.

PERIOD III.

At the close of the second period the pigs had attained an average weight of 120 pounds and the fattening period proper began. One pig was taken from each pen and the same system of feeding was carried on with the remaining ones during a period of four weeks ending November 4th. The results for this period are given in table III.

TABLE III.

PERIOD III.—FOUR WEEKS.

Pens—	9	10	11	12	13	14
	Corn.....	Barley.....	Corn and shorts.....	Barley and shorts.....	2-5 corn, 2-5 shorts, 1-5 oil meal.....	2-5 barley, 2-5 shorts, 1-5 oil meal
Average weight October 7	88.5	117.5	129.	125.	139.2	123.8
" " November 4	98.7	138.	160.	149.	169.	158.
Average gain 4 weeks	10.2	20.5	31.	24.	29.8	20.2
Total weight October 7	354.	470.	645.	625.	696.	639.
" " November 4	395.	552.	800.	745.	845.	740.
Total gain	41.	82.	155.	120.	149.	101.
Feed consumed	328.5	525.5	893.	821.5	924.5	853.
Lbs. gain for each 100 lbs. of feed	12.4	15.6	17.4	14.6	16.1	11.9

It is to be noted in the first place that the pens to which oil meal was fed gave a less return for each hundred pounds of feed consumed than did the corresponding pens fed corn and shorts or barley and shorts. That is: pen 13 returned but 16.1 pounds of gain for each 100 pounds of feed consumed, while pen 11 produced 17.4, showing a positive disadvantage in this case in the use of oil meal. A comparison of pen 14 with pen 12 leads more emphatically to the same conclusion. Pen 13, however, consumed 31.5 pounds more feed than pen 11 and pen 14 consumed 31.5 pounds more feed than pen 12, yet the total gain is six pounds less in pen 13 than pen 11 and 19 pounds less in pen 14 than in pen 12. The behavior of the pigs in this period goes to confirm the results of the previous period and clearly indicates that for this lot of swine oil meal, however valuable for young and

growing pigs, is not adapted to fattening swine.

Comparing now the results obtained by feeding corn with those where barley was used we find that with the exception of pens 9 and 10 the gain is greater with the pens fed on corn than with the pens fed on barley. The total gain of the five pigs in pen 11 was 155; in pen 12, 120. In the lots fed with oil meal the corn fed pigs gained 149 while those consuming barley gained but 101. Moreover, this gain was accomplished with a much less proportional food consumption on the part of corn than of the barley. One hundred pounds of corn and shorts made with pen 11, 16.4 lbs. of gain, while the pigs in pen 12 gained but 14.6 pounds for each one hundred pounds of barley and shorts consumed. A similar difference of 4.2 lbs. of gain per hundred weight of feed consumed in favor of corn is noticed when pens 13 and 14 are compared. These results are diametrically opposed to those obtained in the first two feeding periods, where the advantage in every case lay on the side of the barley. This leads us to the conclusion that barley is inferior to corn for fattening swine while it will compare favorably with corn in the ration of young pigs.

*In an experiment conducted by Prof. W. A. Henry, at the Wisconsin station, for the purpose of determining the value of barley in comparison with corn for fattening hogs, ten hogs, fourteen months old and weighing on the average 208 pounds each, were used. They were divided into two even lots of five hogs each to one of which barley meal was fed and to the other corn meal. He found after continuing the experiment eight weeks that it required 8 per cent more barley meal than corn meal to produce 100 pounds of gain. These results are substantially in accord with those obtained in the third period of this experiment. In both cases the hogs were being fed for fattening and not for growth, and for this purpose there is no question but that corn is better.

In the Journal of the Royal Agricultural Society, Vol. 14, O. S., page 459, is recorded an experiment performed by Sir J. B. Lawes at Rothamstead in February, 1850. He fed a

*Seventh Annual Report Wisconsin Station, page 64.

pen of three pigs on corn meal alone for eight weeks. The pigs consumed 1086 pounds of corn meal and made a gain of 221 lbs., or a return of 20.3 lbs. of gain for each hundred pounds of meal consumed. The average weight of these pigs at the beginning of the experiment was 143 lbs.

In May of the same year he fed a pen of three pigs averaging 147 lbs. in weight on barley meal. The conditions of this feeding period were the same as those of the corn fed lot in the February previous, except that the weather was exceedingly hot for several days during its progress. These pigs made a total gain of 291 lbs. consuming 1644 lbs. of barley, a gain of 17.7 lbs. per hundred lbs. of barley. These pigs were also nearly as mature as the pigs in our experiment at the beginning of the third period, hence our results are not contradictory.

CONCLUSIONS.

In order to exclude the uncertain factor, the amount of pasture which pigs would consume, it was impossible in this experiment to allow the pigs to run either to clover, peas or even good blue grass pasture. The gains made by the pigs even in the pens which showed the best results are therefore small. To make pig growing profitable the brood sows and the young pigs, all their lives up to the time when they are shut up for fattening, should have the run of a good pasture, preferably clover or peas; but to reach conclusions anything like definite in this experiment we were obliged to keep the pigs closely confined.

(1) When fed as the entire ration of pigs weighing on the average 52 lbs. at the beginning of the test, one hundred pounds of barley meal was found to produce as great a gain as 119.5 lbs. of corn meal.

(2) When mixed with shorts in equal parts and fed to pigs of the average weight of 50 lbs., one hundred pounds of barley meal and shorts produced as great a gain as 105.2 lbs. of corn meal and shorts.

(3) When to the mixtures with shorts one-fifth part of oil meal is added then one hundred pounds of barley meal, shorts and oil meal produced as great a gain as 103.3 lbs. of corn meal, shorts and oil meal.

(4) The older the pig grows the more food it takes to produce a pound of gain.

(5) In this experiment the addition of oil meal to the ration of either barley meal and shorts, or corn meal and shorts after the pig had attained an average weight of slightly over a hundred pounds, was deleterious.

(6) The continued use of corn meal as the sole food of growing pigs was found to be productive of too great a tendency to become excessively fat without a normal growth of bone and muscle and to produce unhealthy pigs, while the use of barley alone was not attended with this result.

(7) The pigs throughout the experiment consumed more corn meal and shorts than barley meal and shorts, produced a greater gain with the former than the latter but, except in the third period, at a greater expense of food consumption.

(8) The same relation holds good where oil meal forms a fifth part of the ration.

(9) When fed to pigs weighing 125 pounds or more one hundred pounds of corn meal and shorts produced as great a gain as 119.1 of barley meal and shorts.

(10) When fed to pigs weighing 125 pounds or more one hundred pounds of corn meal, shorts and oil meal, mixed as indicated, produced as great a gain as 135.2 pounds of barley meal, shorts and oil meal.

CORN VS. BARLEY FOR FATTENING HOGS.

W. M. HAYS.

On the 6th of October, 1891, two groups of hogs, taken from a woods pasture where they had been kept in fair growing condition by some grain food, were placed in pens with ample yard room for exercise, and were fed, one corn meal and the other barley meal, to compare these grains for fattening hogs. In each group was a young Essex sow weighing at the beginning about 160 pounds, one Berkshire sow, one Berkshire barrow, and two cross bred Jersey Red Poland China sows, all four of which weighed in the neighborhood of three hundred pounds each. The two groups were well matched as to breeding, appearance, size, etc. They were all in good condition to make rapid gains and the individuals in each pen on the same ration made comparatively uniform gains. Pen A was fed corn meal of good quality and made on an average for the entire period of 51 days one pound of pork for each five pounds of grain eaten or 11.2 pounds of pork for each bushel of corn. Barley meal was fed to pen B, the meal simply being moistened as with the corn. The barley used was from four small lots purchased for feeding our general stock of hogs. As the hogs in pen B showed a decided dislike for one or two lots of this barley the notes were so kept that the results of feeding each lot or quality of barley could be shown in comparison. The barley fed pen B during several days of preliminary feeding and during the first period of sixteen days, October 6th to 21st inclusive, was not relished by the hogs. It was "off color" and had a slightly musty odor. During the second period of seven days, Oct. 22nd to 28th inclusive, good barley was given and was eaten with greater relish by the hogs. During the third period of fourteen days, Oct. 29th to Nov. 11th inclusive, another lot of barley almost as poor as that fed during the

first period was given and with a similar lack of relish shown by the hogs. During the fourth period of fifteen days, Nov. 12th to 26th inclusive, barley of good quality was fed again. The accompanying tabular statements gives the summarized results. Not forgetting the comparison of corn with good barley special attention is directed to the lesser amount of barley eaten per hundred weight of hog when barley lacking flavor was fed as compared with bright barley of good flavor; also to gains resulting.

CORN, GOOD BARLEY AND POOR BARLEY COMPARED.

			No. hogs in lot	Barley meal fed, lbs.....	Corn meal fed, lbs.....	Total gain lbs	Average gain per day per head, lbs....	Pounds feed to lb. gain..	Am't eaten pr 100 lbs. live w't per day.
1st period 16 days.	Corn vs. poor barley.	Pen A.	5		933.	207.	2 3-5	4.5	4.
		Pen B.	5	628.5		77.	1	8.2	2.8
2d period 7 days.	Corn vs. good barley.	Pen A.	5		451.5	116.	nearly 3⅛	3.9	4.
		Pen B.	5	374.		94.	2 4-5	4.	3.6
3d period 14 days.	Corn vs. poor barley.	Pen A.	5		829.5	170.	2 3-7	4.9	3.2
		Pen B.	5	507.5		33.	½	15.4	2.3
4th period 14 days.	Corn vs. good barley.	Pen A.	5		935.	135	1 4-5	6.9	3.4
		Pen B.	5	784.		101	nearly 1 2-5	7.8	3.4

SUMMARIZED AVERAGE RESULTS.

	Wt. at beginning of 1st period.....	Wt. at end of 4th period..	Corn to 1 lb. gain for the whole time.	Barley to 1lb. gain for the whole time.	Good barley to 1lb. gain	Poor barley to 1lb. gain
Pen A	1362	1990	5.			
Pen B	1364	1669		7.5	5.9	10.3

The comparison of corn and good barley was hardly fair at any time. The fact that good bright malting barley is of more feeding value than that considerably "off" color and flavor is certainly here illustrated.

CORN MEAL, BARLEY MEAL AND A MIXTURE OF 9-10 BARLEY MEAL AND 1-10 OIL MEAL COMPARED.

W. M. HAYS.

June 22nd to July 21st inclusive, 1891, five groups of hogs were fed to compare corn, barley and a ration of 9-10 barley and 1-10 old process linseed oil meal. Groups A and B were made up of a lot of shoats of mixed breeding farrowed the fall previous. Each of these two groups contained two sows and one barrow ¾ Jersey Red and ¼ Poland China; one sow and one barrow ½ Berkshire, ¼ Jersey Red and ¼ Poland China; and three ½ Jersey Red and ½ Essex, in all eight, and so divided that each pen was of the same weight and otherwise well mated. Groups C, D and E each had one yearling full blood Berkshire sow of the family known on the station farm as Bell, one of the Nora family and one of the Hipplewaith family, making three hogs in each pen, the groups being well proportioned. To pen C corn was given the same as to pen A; pen D was fed barley the same as B and pen E was fed a ration of 9-10 barley and 1-10 oil meal. The meal for all groups was mixed with only enough water to moisten it without making the mixture sloppy. The feed for morning was mixed in the evening and noon and evening feeds were mixed in the morning, thus always insuring that the meal was not sour. The hogs were all given access to salt, sulphur and charcoal mixed together in boxes. They were all similarly situated as to shade, small yard to exercise in, water adlibitum, etc. The desire for green feed at this time of year so strongly manifested itself that, on July 2nd the feeding of mixed oats and peas, nearing the flowering stage was begun and continued to the end. For six days pens A and B were given eight pounds daily of this green stuff and pens C, D and E were given five pounds each. On July 7th

the allowance of green peas and oats to pens A and B was increased to 13 pounds daily and without farther change the feeding was thus continued to the end. Each group was fed all the meal it was found safe to give and avoid overfeeding. The following tabular statement shows the general result:

CORN MEAL, BARLEY MEAL AND 9-10 BARLEY 1-10 OIL MEAL COMPARED.

Pen.		Pounds grain fed.....	Pounds green peas & oats fed.....	Average gain per day and head.....	Pounds grain to 1 lb. gain..	Total gain.....	Pounds grain eaten per day per 100 lbs. live weight...
A	Corn meal.....	1277.5	259	1.14	4.7	273.3	4
B	Barley meal..	1274.	159	1.04	5.08	250.8	4.
C	Corn meal.....	675.	100	1.15	6.3	106.6	3.4
D	Barley meal..	868.	100	1.06	5.8	149.2	4.
E	9-10 barley.	811.8	100	1.07	5.6	106.	4.2
	1-10 oil meal	90.2					

With pens A and B considerable less corn than barley was consumed to make a pound of pork while in pens C and D the result is reversed. The addition of 1-10 of oil meal to the barley given in pen E made only a slight decrease in the pounds of grain needed to make a pound of gain.

WET VS. DRY FEED.

CLINTON D. SMITH.

The object of this experiment was to aid in determining whether a ration composed of two parts corn meal, two parts shorts and one part old process oil meal would produce when fed dry, greater or less gain than when mixed with sufficient water to form a thick slop. Incidentally a study was made of the value of charcoal.

Twelve pigs were selected for this experiment, six from a litter whose dam was a half Duroc and half Yorkshire sow, the sire an Essex boar. These pigs were either black or white and were farrowed June 11, 1891. The litter from which the other six pigs were selected was farrowed June 7th by a Duroc Jersey sow, the sire being a recorded Berkshire. These pigs were all red.

On the first day of August these twelve pigs were divided into four groups of three each and a preliminary feeding period of one week began. The average weight of the pigs at that time was 28½ pounds. At the close of the week, August 8, it was found that the gains of the pigs had not been uniform but it was decided to carry forward the experiment with the pigs arranged as they were, due care having been taken at the outset to have the pens as evenly matched as to thriftiness, weight and breeding as possible. The pigs were accordingly re-weighed August 8th and the experiment proper began. Pens I and IV received their feed mixed into a thick slop with cold water, pens II and III were fed the same kind of food but dry. The feed for all pens was a mixture by weight of two parts corn meal, two parts shorts and one part old process oil meal. Each lot was fed in a small pen with a large yard adjacent giving the pigs the necessary exercise. Pens I and II were fed all the charcoal they would eat while pens III and IV had none. The results of the trial which extended over a period of sixteen weeks ending November 28th are recorded in the following table:

TABLE IV.

Pens—	I.			II.			III.			IV.		
	Feed Wet. (With Charcoal.)			Feed Dry (With Charcoal.)			Feed Dry.			Feed Wet.		
	Black Barrow	Red Sow	Red Barrow	Black Sow	Blk Barrow	Red Sow	Red Sow	Red Barrow	Blk Barrow	Red Sow	Blk Barrow	Black Sow
Weight August 8	21.5	36.	43.5	30.5	20.5	34.5	41.5	32.5	24.5	36.5	26	28.5
Weight November 28	118.5	147.	178.5	119.	86.	126.	132.5	124.	91.	136.	95	129.
Gain	97.	111.	135.	88.5	65.5	91.5	91.	91.5	66.5	99.5	69	100.5
Total gain of pen			343.			245.5			249.			269.
Feed consumed			1500.5			1085.			1140.5			1233.5
Charcoal eaten			64.			80.	none	none	none	none	none	none
Gain per 100 lbs. of feed			22.2			22.6			21.8			21.8

The greatest gain made by any pen was 346 lbs., made by pen I, which consumed 1500.5 lbs. of feed. This was a gain of 22.2 lbs. for each hundred pounds of food consumed. Pen II consumed but 1085 lbs. of feed and made a gain of 245.5 lbs. or at the slightly better rate of 22.6 lbs. of gain for each hundred pounds of grain eaten. Pen II consumed 80 pounds of charcoal, 25 per cent. more than the amount eaten by pen I. Whether this was due to the feed being given dry to pen II and wet to pen I there was nothing in the behavior of the pigs to indicate. Looking at the economy of food consumption alone no great advantage seems to lie with either method of food preparation; but, when we consider that the one pen converted 50 per cent. more feed than the other into pork in the same length of time and equally as economically, if there is any profit in feeding the grain at all the aggregate profit of one pen must be 50 per cent. greater than that of the other.

Pen III received no charcoal and was fed dry feed. Of this these three pigs consumed 1140.5 lbs. and made a gain of 249 lbs. Pen IV received no charcoal but the feed was fed in the form of a thick slop. The pigs in this pen made a gain of 269 lbs. from 1233.5 lbs. of feed. The rate of gain in proportion to food consumed is identical with that of pen III, with which it is comparable. As in the case of the other two pens the pigs receiving the feed wet ate more of it and made a correspondingly larger gain. Judging from the behavior of the pigs in these four pens it may be safe to conclude that for the ordinary farmer who desires his pigs to grow as rapidly as possible it is an advantage to feed the food wet rather than dry.

It is to be noted that the pens fed charcoal produced 22.2 and 22.6 pounds of gain for each hundred pounds of food consumed while the pens without charcoal produced but 21.8 pounds a difference of .6 of a pound in favor of the pens receiving the charcoal.

The two pens receiving charcoal taken together made a gain greater by 70.5 pounds than the pens receiving none and consumed but 211.5 pounds more feed, showing a distinct benefit from the use of the charcoal.

A point of importance as to its bearing on the experiment as a whole is the difference in gain made by the individual pigs in each pen. While fed and treated in every way the same, the six red pigs gained 619.5 pounds and the six black ones 487 pounds, a difference of 132.5 pounds or more than one third of the entire gain of the black pigs. Unfortunately the amount eaten by each pig was not separately kept and we can only presume that the red pigs ate proportionately more feed than the black ones. However this may be it is evident that the profit in swine feeding depends largely upon the quality of the hogs selected to feed. Individuality plays too, an important part in all feeding experiments.

A German writer in the Milch-Zeitung, page 421, May 30th, 1888, has this to say in regard to feeding meal dry or wet: "Though, it is true that the two methods of feeding meal, dry and mixed directly in the drinking water of swine, obtain, it may be said that the last method though the more common is the least practical. It should be remembered also that the hog has a very simple digestive apparatus and that in his voracity he gulps down without chewing whatever he can thus swallow. Chewing, that is the mixing of the dry food with the saliva, is the first act of digestion. If now the meal is put directly in the drinking water, the hog gulps it down without mixing with it any appreciable quantity of saliva. Digestion which is the abstraction of the valuable ingredients from the food is thereby decidedly lessened and the food materials pass through the alimentary canal unutilized. But if the meal is given dry the hog can not swallow it without mixing saliva with it."

"Dr. Bruemmer, director of the agricultural school in Kappeln, (Schleswig-Holstein) has concluded from his experiments that cracked and whole grain are better digested and more effective on account of a more thorough mixture with saliva taking place before swallowing. Unfortunately the record of his experiments are not at hand."

"I have for several years fed meal dry, using two troughs in the pig pen so that the pigs could get the meal from one trough and drink from the other and I have been very well satisfied with the result."

On page 83 of the fourth annual report of the Wisconsin station Professor Henry urges the farmers to "try giving corn meal, shorts, bran or barley meal dry in troughs supplying plenty of water of course." In the year following he performed some experiments to more thoroughly test this question. He took six hogs and divided them into lots of three each. The three hogs of one lot weighed at the beginning of the experiment 343.5 lbs. and of the other lot 346 lbs. Both lots were supplied with water in a separate trough. The ration consisting of equal parts of corn meal and shorts was fed dry to one lot and wet with cold water to the other. After feeding for 34 days the lots were reversed and after a preliminary feeding of a week the experiment was repeated placing each hog on both sides of the trial. A duplicate trial was being conducted with four other hogs with a ration of two parts corn meal and one part shorts fed dry to two of the hogs and wet to the other two. The tables below show the result of the trials:

FIRST EXPERIMENT—THREE HOGS ON EACH SIDE. EACH PERIOD 34 DAYS.

Wet Feed.				Dry Feed.			
	Weight at beginning	Gain	Feed Eaten		Weight at beginning	Gain	Feed Eaten
	lbs.	lbs.	lbs.		lbs.	lbs.	lbs.
First Period, Lot 1	346	165	622	Lot II	343	127	570
Second Period, Lot 2	504	172	739	Lot I	512	128	658
		337	1,361			255	1,228

SECOND EXPERIMENT—TWO HOGS ON EACH SIDE. EACH PERIOD 34 DAYS.

First Period, Lot 1	343	111	508	Lot II	331	63	472
Second Period, Lot 2	448	109	532	Lot I	467	98	511
		220	1,040			161	983

In this experiment by Professor Henry the pigs, where the feed was wet, ate more of it than where dry, made a larger

gain and a less relative consumption of food. One hundred pounds of the corn and shorts produced a gain of 24.8 pounds when fed wet and but 20.7 pounds when fed dry. The results of our experiment are not in accord with the results here given in this one respect. Although our pigs ate more of the wet feed than of the dry, they made no greater gain on the same quantity of feed in one case than in the other. While it is true as a general rule that the more feed an animal can be induced to eat and digest the greater is the profit from feeding and the greater gain made by the animal, the statement above cited from the German writer is entitled to some weight. The difference between the amount which an animal can be induced to eat and the amount required to maintain his existence is at the best but very small and is a very small per cent of the total amount eaten. While the ration of maintenance is an indefinite quantity the results of our experiment seem to indicate that a greater proportion of the feed was actually digested and assimilated when fed dry than when fed wet. To the practical pig feeder, however, who is anxious to make with his hogs the greatest gain in the shortest possible time this advantage is completely overbalanced by the other consideration that the hogs take more kindly to the wet feed and make with it the greatest gains in a given time.

When pigs are shut up in close quarters some food, perhaps condimental in its nature like charcoal or mixtures of charcoal, ashes, salt and other ingredients is highly relished by them and as our figures show is a source of profit to the farmer.

UNIVERSITY OF MINNESOTA.

Agricultural Experiment Station.

BULLETIN No. 23.

SEPTEMBER, 1892.

WHEAT.

I.—MILLING AND BAKING TESTS. II.—CO-OPERATIVE TESTS WITH SELECTED SEED WHEAT.

III.—THE FRIT FLY—PRELIMINARY REPORT UPON AN INSECT INJURIOUS TO WHEAT.

☞ The Bulletins of this Station are mailed free to all residents of the State who make application for them.

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WHEAT.

MILLING AND BAKING TESTS.

D. N. HARPER.

Twenty-five bushels of each of the following varieties of wheat were milled:

		Test weight as milled.
1.	Pure Scotch Fife	63.5 lbs.
2.	Pure Blue Stem	59 "
3.	Pure Ladoga	57 "
4.	Scotch Fife	61.25 "
5.	Scotch Fife slightly bleached	60 "
6.	Scotch Fife slightly frosted	58.5 "
7.	Scotch Fife badly frosted	58 "
8.	Scotch Fife badly bleached	57.25 "

All of the wheats were grown upon average Red River valley soil near Hallock. Numbers 4, 5, 6 and 7 were from the same farm and grown from the same seed, any differences were the effects of bleaching or frost. The Ladoga was the poorest appearing wheat, smutty, and in a characteristic shrunken condition. The slightly frosted wheat was of the kind commonly called "brac" frosted, and the badly frosted had green grains, and all were shrunken.

The pure Scotch Fife was not in perfect milling condition, as it was a little too hard, and should have been steamed before milling; it broke flinty and the shorts contained more granules of the heart of the wheat than it should have contained. The Ladoga was in the best condition for milling, the Blue Stem next. No. 4 [Scotch Fife] had been threshed while wet, and had been dried out on the floor of the granary and was not in perfect condition on that account. The bleached and frosted wheats were in good condition except for the characteristics mentioned.

The mill used was a Norman & Nordyke short system, belonging to Russell & Hughs of Hallock. The daily capacity of the mill was fifty barrels. In the mill two reductions are made on the wheat, and four smooth roll reductions on the

middlings. The bolting and purifying system comprises one purifier and aspirator, four scalpers, four interelevator rolls and one bran duster.

The Ladoga milled the most easily, the bran cleaned the best, the middlings purified best and came out in the best form. Pure Scotch Fife came second as to mechanical loss of milling and then the Fife No. 4 and Blue Stem. The bleached wheats milled well but did not finish well. The frosted wheats milled badly, the bran was brittle, pulverized easily and could not be cleaned up well; the middlings were correspondingly dark and hard to reduce and purify.

In milling, the conditions were kept as nearly uniform in all cases as possible, and the yields of the various flours, and other products are strictly comparable. In the following table the number of pounds of flour returned as well as of all other products are given, together with the total number of pounds of wheat run through, exclusive of screenings, and the total number of pounds recovered from the mill.

POUNDS OF WHEAT MILLED AND RETURNED.

No. of Sample.	Kind of Sample.	FLOURS.			OFFALS.			TOTALS.		Per cent. Loss—, Gain +
		Patent....	Straight..	Four X....	Bran.....	Shorts.....	Germ.....	From mill	Wheat run through...	
1	Pure Scotch Fife...	339	544½	96.5	192	25	121.5	1318½	1341	-1.83
2	Pure Blue Stem....	335½	690.5	67	232	33.5	74	1432½	1460	-1.91
3	Pure Ladoga.....	290.5	504	62	210	26	77½	1170	1249	-6.35
4	Scotch Fife	321	626½	15	263	138	88.5	1452	1457½	-1.39
5	Scotch Fife slightly bleached	317	651	38	226	151	75	1458	1456½	x .10
6	Scotch Fife slightly frosted..	302	559.5	64	252½	220.5	108.5	1507	1437	x4.87
7	Scotch Fife badly frosted....	198	507	131	234	36	139.5	1245.5	1434	-13.2
8	Scotch Fife badly bleached.....	301	628	35	248	125	52	1389	1453½	-4.43

These results when expressed in percentages for the purpose of affording a more uniform basis of comparison, are tabulated below. In the first row of figures opposite each kind of wheat the per cent. of each milled product is given, based upon the amount of all returned from the process; in the second row is given the per cent. returned based upon the amount put into the hopper exclusive of the amount of screenings.

PER CENTAGE AMOUNTS RETURNED.

	KIND OF SAMPLE.	FLOUR.			OFFALS.			TOTALS.		Loss—	Time Required to Mill.
		Patent.	Straight.	Four X.	Bran.	Shorts.	Germ.	Flour.	Offals.		
1	Pure Scotch Fife	25.71 25.28	41.29 40.60	7.34 7.05	14.56 14.32	1.89 1.86	9.21 9.06	74.34 72.93	25.66 25.24	1.83	1 hour and 50 min.
2	Pure Blue Stem	23.42 22.98	48.20 47.29	4.67 4.58	16.20 15.89	2.34 2.29	5.17 5 06	76.29 74.85	23.71 23.24	1.91	2 hours and 10 min.
3	Pure Ladoga	24.83 23.25	43.08 40.35	5.30 4.96	17.95 16.81	2.22 2.08	6.62 6.20	73.21 68.56	26.79 25.09	6.35	2 hours and 45 min.
4	Scotch Fife	22.11 22.02	43.14 42.98	1.05 1.03	18.11 17.04	9.50 9.47	6.09 6.07	66.30 66.03	33.70 32.58	1.39	2 hours and 25 min.
5	Scotch Fife slightly bleached	21.75 21.76	44.62 44.69	2.61 2.61	15.51 15.52	10.36 10.37	5.15 5.15	68.98 69.06	31.02 31.04	gain .10	
6	Scotch Fife slightly frosted	20.04 21.02	37.12 38.94	4.26 4.45	16.75 17.57	14.63 15.34	7.20 7.55	61.42 64.42	38.58 40.46	gain 4.87	4 hours and 20 min.
7	Scotch Fife badly frosted	15.89 13.81	40.71 35.36	10.52 9.13	18.79 16.32	2.89 2.51	11.20 9.73	67.12 58.30	32.88 28.56	13.14	2 hours.
8	Scotch Fife badly bleached	21.67 20.71	45.22 43.21	2.52 2.41	17.85 17.06	9.00 8.60	3.74 3.58	69.41 66.33	30.59 29.24	4.43	

These results when expressed in percentages, taking as a basis the result of the largest amount of flour received in each case as 100, will stand in the following relation to each other for the flours:

	Patent.	Straight.	Four X.	Total.
Pure Scotch Fife	100.	85.66	69.77	97.44
Pure Blue Stem	91.09	100.	44.39	100.00
Pure Ladoga	96.58	89.38	50.38	95.96
Scotch Fife	85.99	89.50	9.98	86.91
Scotch Fife bleached	84.59	92.57	25.76	90.42
Scotch Fife badly bleached	84.29	93.82	23.95	90.98
Scotch Fife badly frosted	61.80	84.56	100.	87.98
Scotch Fife slightly frosted	77.94	77.24	40.49	80.51

The amounts of wheat taken for the tests were nearly the same in all cases, and the lengths of time required for milling as given in the table are comparable.

As to the character of the flour the pure Scotch Fife had the best feel and appearance; the Ladoga the worst, and the others range, after the Scotch Fife, in this order: Blue Stem, No. 4, badly bleached, slightly bleached and frosted. These last have a weak, sticky feel and a greyish caste. The bleached flours are weak and very white. The Ladoga has a very peculiar saffron color, quite different from anything else.

BAKING TESTS.

Bread was baked from each lot of flour, and of the patent and straight flours a great many loaves of each were baked at different times to secure reliable results on the following points: (1) the amount of flour necessary to make the best bread with a definite quantity of yeast liquid, (2) the "strength" of the flour as determined by the dimensions of the loaf made from a definite quantity of flour and yeast mixture, (3) the absorptive and retentive capacity of the flour as determined by the weight of the bread made with a definite quantity of yeast mixture and flour, (4) the quality of the bread as determined by its color and texture. The results are as follows:

I. Amount of flour needed to definite quantity of yeast mixture. The ratios of the weight of flour taken are as follows:

Badly bleached	95.52
Bleached	97.18
Slightly frosted	92.84
Badly frosted	94.74

No. 4 ..... 93.68
Pure Blue Stem 94.61
Pure Scotch Fife 93.46
Ladoga 98.62

The above figures are the averages of the ratios obtained in separate tests.

II. The ratios of strength as obtained by the measurement of the dimensions of the loaves are as follows:

Badly bleached 95.89
Slightly bleached 90.45
Slightly frosted 96.77
Badly frosted 95.85
No. 4 ..... 93.71
Pure Blue Stem 98.73
Pure Scotch Fife 92.74
Ladoga 88.16

III. The absorptive and retentive capacity of the flours are in the following ratios:

Badly bleached wheat 92.31
Slightly bleached 94.05
Slightly frosted 92.09
Badly frosted 92.21
No. 4 [Scotch Fife] 92.72
Pure Blue Stem 92.55
Pure Scotch Fife 99.27
Ladoga 93.82

IV. Color and texture in following ratios:

Badly bleached ..... 99.
Slightly bleached ..... 95.
Slightly frosted ..... 93.
Badly frosted ..... 91.
No. 4 (Scotch Fife) ..... 98.
Pure Blue Stem ..... 97.
Pure Scotch Fife ..... 100.
Ladoga ..... 50.

The color and texture are matters of individual judgment. To eliminate or reduce this as much as possible I had my assistant weigh out the flours and number them indiscriminately, keeping the names and numbers secret from me. In

every case my judgment arranged the loaves in the order stated while the percentages varied slightly.

The pure Scotch Fife bread was clearly the best in every case as to color, texture, and odor. It was a bright, rich, creamy white. The badly bleached Fife came next but was deficient in the richness of appearance. The Fife (No. 4) was richer looking than the bleached but a little dingy in color. Blue Stem was as rich looking as any and of good texture and had a very slight bluish or greenish tinge. The slightly bleached wheat looked weak and rather dingy. The slightly frosted was greyish and the worse frosted noticeably more so. The Ladoga retained its saffron color but intensified and was of quite a disagreeable appearance.

All these remarks and ratios are drawn directly from the results with patent flours but are equally applicable to results from the straight and red dogs.

In the straight flours the characteristic colors of the Ladoga and Blue Stem were more noticeable than in the patent.

CONCLUSIONS.

The pure Scotch Fife wheat proves to be the best wheat, the Blue Stem wheat next and the Ladoga very poor. Any injury done to wheat by reason of its being threshed while wet, bleached or frosted, injures it for milling and for making good bread, the extent of injury varying.

The Ladoga has been shown to be a failure as to yield, both as to quantity and quality, and the milling and baking tests show it to be equally worthless.

SEED WHEAT.

CO-OPERATIVE TESTS WITH SELECTED SEED.

In bulletin No. 15 of this Station issued in February, 1891, notice was given that the Hon. Chas. A. Pillsbury had kindly placed at the disposal of the Station, for free distribution, some pure scotch fife wheat. The object of this generous gift was to demonstrate the benificial results arising from the careful selection of seed. The wheat was distributed under the following conditions:

"1. It shall be planted on new ground, that which has not grown a crop, or on summer fallowed land, or on land which has just raised a crop of potatos, corn or millet.

2. A record shall be kept of the date when planted, size of plot, time when ripe, and dates when harvested and threshed.

3. A small sample of the crop together with a copy of the record shall be sent to the Station.

4. It shall be seeded at the rate of at least one bushel per acre. The wheat will be distributed in packages not to exceed five bushels, and it is suggested that one bushel be the rate at which it is seeded when a press drill is used, and a bushel and a peck when seeded broadcast.

5. A bushel from the crop shall be sent by each farmer to the State Fair of 1891. Mr. Pillsbury will give a premium of $100, divided in three different prizes, for the best samples submitted there. The expense of transportation to the State Fair will be borne by the Experiment Station and the wheat will then be the property of the Experiment Station. This wheat will be distributed next year.

Those desiring this seed will need to make early application, stating the amount of land under cultivation, whether light or heavy prairie land or timber, and that they will observe the requirements."

Over seven hundred applications were received for seed and

the supply was soon exhausted. All of the railroads in the state generously aided in carrying out this experiment by distributing free of charge the wheat along their lines.

The seed selected for this experiment was pure scotch fife wheat.

Owing to unavoidable delay in procuring this wheat it was impossible to clean it by suction blast as was intended. It was, however, well cleaned through a Champion cleaning mill and cockle machine, and was in good condition for seeding. Its germinating power had been tested and found to be high.

This wheat was perfectly pure scotch fife, having been carefully selected for a number of years. The history of the wheat during this time may be interesting and should prove profitable now. It should suggest to each farmer receiving this seed means to keep it pure and improve it.

In 1881 a Red River Valley farmer found a clump of 22 stalks of wheat growing from a single grain, and which matured much earlier than the remaining stalks of wheat in that field. These stalks were pulled when ripe, carefully preserved and threshed by hand. There were obtained 860 grains of wheat, 760 of which were selected for seed and planted in 1882 six inches apart each way on a clean piece of land. These grains yielded 12 pounds of wheat, or at a rate of 40 bushels per acre. In 1883 the seed of 1882 was sown on another piece of clean land in rows 12 inches apart and thick in the rows. The wheat was given thorough cultivation and yielded 17 bushels, or at a rate of 72 bushels per acre. The crop was harvested by itself and garnered in a spare room in the farm house. It was threshed out by hand. In 1884, after cleaning, the wheat was sowed on land which had for the preceding five years been in pasture. This land had been turned down and seeded to timothy because of a rank growth of wild buckwheat. In 1884 the buckwheat appeared again and overran the crop, cutting the yield down to 15 bushels per acre, but the quality was good. The crop was carefully harvested and threshed, keeping the wheat separate from all other lots. Before threshing a half day was spent by two men in cleaning out of the

threshing machine all grains of wheat and weed seeds.

The same care has been observed to keep the wheat pure since that time. It has been grown on new or summer-fallowed land and harvested and threshed separately as long as two kinds of wheat were raised on the same farm. In 1886 it averaged 44 bushels per acre; in 1887 the quality was fine but the winds decreased the yield; in 1888 it escaped the rust and frosts then prevalent; in 1889 and 1890 the quality and yield has been good, the latter averaging in 1890 27½ bushels per acre.

Every two years this seed has been exchanged between two farms 30 miles apart. Although both are prairie farms the beneficial results have been noticeable.

To continue the purity of this wheat and to improve its quality should be the aim of every farmer. This can be done by observing the conditions of the distribution; by seeding on clean ground, harvesting and threshing separately from all other varieties of wheat.

Seed was sent into every county of the state, and owing to the lateness of the following season at which many farmers were compelled to do their threshing on account of the large yield of all grain crops for that year, full reports were not received from many until early in the present year. A few reported loss by a heavy hail storm, while others, especially from the extreme northern portion of the state reported that the wheat crop in general was late on account of heavy spring rains; others reported damage from chinch bugs and late sowing. A large quantity of seed was sent into every wheat growing section of the state, and the season was very favorable for this crop; hence the results are strictly comparable as to yield and weight per bushel and time of maturing, except for the samples damaged by hail, late sowing or chinch bugs as noted. The difference in yield per acre, weight per bushel and time of maturing, color and plumpness are due to the different climatic and soil conditions.

The report of the samples entered for the premium given by Mr. Pillsbury is given first; and then the report on all other samples received up to January 15th, 1892, are tabulated in subsequent pages:

W. F. Cross, Secretary State Fair, Hamline, Minn.:

Dear Sir: The samples of wheat entered for the prizes of the Hon. Charles A. Pillsbury have been adjudged according to the basis of award published in the premium list, and which we quote:

BASIS OF AWARD.

	Points.
Weight per bushel on a scale of	100
Color of grain	100
Plumpness	100
Percentage of glutin	100
Quality of glutin	100

The prizes will be awarded to the five best samples in the order in which they approach the 500 points mark. Of all the samples entered thirteen are much the best and are of nearly equal value, and the result of judging these is given in detail.

First—A. N. Johnson, Hoffman, Grant county.

	Points.
Weight per bushel—62 pounds	100.0
Color	96.5
Plumpness	98.0
Amount of glutin	100.0
Quality	97.5
Total,	492.0

Second—Fred Musner, Millerville, Douglas county.

Weight—62 pounds	100.0
Color	98.0
Plumpness	98.0
Glutin	91.8
Glutin, quality	96.5
Total,	484.3

Third—O. E. Samuelson, Vasa, Goodhue county.

Weight—61 pounds	98.4
Color	100.0
Plumpness	100.0
Glutin	92.0
Glutin, quality	90.0
Total,	480.4

Fourth—Peter Thompson, Cottage Grove, Washington county.

Weight, 61.5 pounds	99.2
Color	96.5
Plumpness	96.5
Glutin	88.7
Glutin, quality	96.5
Total,	477.4

Fifth—E. S. Olsen, Milan, Chippewa county.

Weight, 61 pounds	98.4
Color,	96.5
Plumpness,	97.0
Glutin	91.33
Glutin, quality	92.5
Total,	475.73

Sixth—A. J. Hurley, Lanesboro, Fillmore county.

Weight, 62 pounds	100.
Color	98.
Plumpness	98.
Glutin	83.33
Glutin, quality	95.5
Total	474.83

Seventh—M. H. Smith.

Weight, 61 pounds	98.4
Color	97.
Plumpness	99.
Glutin	77.33
Glutin, quality	99.
Total,	470.73

Eighth—D. L. Wellman, Frazee City, Becker county.

Weight, 61 pounds	98.4
Color	96.5
Plumpness	98.
Glutin	79.3
Glutin, quality	97.5
Total,	469.7

Ninth—L. Kiel.

Weight, 61 pounds	98.4
Color	96.5
Plumpness	98.6
Glutin	81.3
Glutin, quality	91.5
Total,	466.3

Tenth—Theodore Lukens, Lukens, Wadena county.

Weight, 61.5 pounds	99.2
Color	97.0
Plumpness	98.0
Glutin	75.8
Glutin, quality	95.5
Total,	465.5

Eleventh—R. E. Patterson, Pelican Rapids, Otter Tail Co.

Weight, 61.5 pounds	99.2
Color	96.5
Plumpness	98.0
Glutin	73.8
Glutin, quality	98.0
Total,	465.5

Twelfth—J. G. Nelson, Parker's Prairie, Otter Tail county.

Weight, 61 pounds	98.4
Color	96.0
Plumpness	97.5
Glutin	70.2
Glutin, quality	95.5
Total,	457.6

Thirteenth—D. W. Swingh, Appleton, Swift county.

Weight, 62 pounds	100.0
Color	96.5
Plumpness	97.5
Glutin	70.0
Glutin, quality	92.0
Total,	456.0

The prizes are therefore awarded, in the order named, to A. N. Johnson, Fred Meisner, O. E. Samuelson, Peter Thompson and E. S. Olsen. One requirement in sending samples was that all grain submitted should be taken from the machine, and not specially cleaned. As a result all the samples have some weed seeds which, by cleaning, would be removed and the weight per bushel would be thus increased.

But eighty-nine entries were received in time for the fair, and it is quite probable that better samples could have been sent were it not that the fair came too early for the late crop of the year. The major part of the seed was sent into the more northern portions of the state, and at the time the fair was held only a few farmers there had been able to thresh the grain.

D. N. HARPER,
A. C. CLAUSEN,
THOMAS C. HODSON.

Abreviations used in the following tables: pot.—potatoes the previous crop. B't—bright. b.c.—broat cast seeder. subs.—subsoil. B. S.—Blue Stem. Blk.—black.

BLUE EARTH COUNTY.

No.	Name of Person.	Town.	Kind of Soil.	Date. Seeded	Date. Ripe	Days maturing	Weight per bushel	Yield per acre	Grade	Notes and Remarks.
350	E. D. Cornish	Vernon	Heavy dark loam	4-28	8-11	105		21		Potatos in 1890.
351	P. McGrath	Good Thunder		4-27	8-17	112		19	1 N	Land not in good condition. Deep b't amber to very slightly starchy.
352	R. L. Houk	" "	Black sandy loam	4-24	8-8	106	62	30	1 H	Potatos in '90. This wheat *much* better than my own.
435	Garry S. Haigh	Mankato	Heavy black loam	4-23	8-8	107		12		Potatos in 1890.

BROWN COUNTY.

No.	Name of Person.	Town.	Kind of Soil.	Date. Seeded	Date. Ripe	Days maturing	Weight per bushel	Yield per acre	Grade	Notes and Remarks.
357	Paul Lehman	New Ulm		4-25	8-6	107	60	15	1 N	Weather too dry. Damaged by rust. Deep amber to starchy.

BECKER COUNTY.

No.	Name of Person.	Town.	Kind of Soil.	Date. Seeded	Date. Ripe	Days maturing	Weight per bushel	Yield per acre	Grade	Notes and Remarks.
359	D. L. Wellman	Frazee City		4-24	8-12	110	62	37	1 H	L't b't amber inclining to starchy. Good season.
361	J. M. King	Frazee City		5-4	8-17	105	63	28	1 N	Corn and millet in '90. Rust in spots. 50% starchy.
439	John Ruff	Frazee City	Light sandy loam, new	4-4	8-20	118	64	40	1 N	Fifty per cent starchy. Corn and potatos in '90. Season good.

BENTON COUNTY.

No.	Name of Person.	Town.	Kind of Soil.	Date. Seeded	Date. Ripe	Days maturing	Weight per bushel	Yield per acre	Grade	Notes and Remarks.
354	A. H. Gates	Rice	Heavy prairie	4-23	8-12	111	63	33	1 N	Nearly all more or less starchy.
355	J. H. O'Keefe	Foley		4-24	8-12	110	63	39	1 H	Corn in '90, clay soil. L't b't amber.

CHIPPEWA COUNTY.

322	N. K. Hogan..	Hogan	Heavy prairie, new land ..	4-24	8-11	109	61		1 H	Due to dry weather only ⅓ of seed sprouted. Deep amber, dirty and shrunken.
328	S. S. Saterlie	Hogan	Blk heavy loam, new land	4-22	8-7	107	62		1 H	Deep amber to very slightly starchy.
323	Hans Larson	Milan	New light soil	4-24	8-9	107	62	22	1 H	Bright amber
324	Ole H. Olson	Milan	Light bottom land	4-28	8-12	106	59		1 H	He thinks this wheat rusts more than B. S. Deep amber. Shrunken.
325	J. H. Klovestad	Milan	New breaking	4-26	8-2	98	61		1 H	B't amber inclining to starchy.
326	E. S. Olson	Milan	Heavy prairie	4-24	8-8	106	62	33	1 H	B't amber.
	John Barnett	Louriston	Black loam, prairie	5-1	8-12	103		24		This wheat is not better than B. S. in his opinion.
	J. A. Hurley	Louriston	Light black prarie	4-6	8-6	122		26	1 H	

CLAY COUNTY.

339	D. O'Donnell	Hawley		5-3	8-21	110		26		Corn in '90. Better than my own S. F. but not better than White Russian.
340	F. W. Cummings...	"					61	20		Light bright amber.

COTTONWOOD COUNTY.

299	M. N. Cadwell	Windom	New land	4-30	8-20	112	63	20	1 H	Light bright amber, some starchy. Too dry when seeded, otherwise would have raised 40 bushels.
303	Adam Burtley	MountainL'ke	Light loam	5-6	8-10	96		7		Damaged by rust very much.
306	F. M. Dyer	Windom	Light loam	4-30	8-15	107	60	15	1 N	Extremely weedy.
307	S. Huntington	Windom	Light loam	4-30	8-17	109	60	15	1 N	Potatos in '90. Seeded too late. Weedy pigeon grass.

CHISAGO COUNTY.

317	J. W. Browning...	Harris.	Light sandy prairie	5-1	8-15	106	63	13	1 N	Pot. in '90, very large and starchy.
319	E. M. Brown	North Branch.	Sand and clay mixed		8-10		62	22	1 N	Very large and all starchy.

DOUGLASS COUNTY.

No.	Name of Person.	Town.	Kind of Soil.	Date. Seeded	Date. Ripe	Days Maturing	Weight per bushel	Yield per acre.	Grade	Notes and Remarks.
288	James Wagner	Millerville	New brush land	4-23	8-15	114	63.2	40	1 N	Large grain; 75% quite starchy. Better than his own.
292	Fred Musner	"	Blk heavy loam, clay subs.	4-24	8-15	113	62.2	34	1 H	Damaged by hail and drouth. Deep amber to very slightly starchy.
289	Wm. Wilkin	"	Heavy loam	5-1	8-22	113	61	35	1 H	Light bright amber, medium, inclining to starchy.
290	P. C. Anderson	Van	Timber cleared in 1889	5-1	8-13	104		40	1 N	Corn in '90; 60% starchy. Weedy pigeon grass.
293	J. S. Reed	Kensington	Heavy loam, clay subs.	4-21	8-18	119	62		1 H	L't b't amber inclining to starchy.
294	J. E. McKinley	Osakis	Timber land, light	4-24	8-10	108	63	18		Corn in '90. Quite starchy.
422	F. von Baumbach.	Alexandria	Sandy loam, gravelly subs	4-18	8-11	115		42	1 H	Season 25% better than last three years.

DAKOTA COUNTY.

No.	Name of Person.	Town.	Kind of Soil.	Date. Seeded	Date. Ripe	Days Maturing	Weight per bushel	Yield per acre.	Grade	Notes and Remarks.
285	Wm. McEliot	Lakeville	Rich sandy loam	5-7	8-25	110	60	17.5		Corn in 1890.
286	J. C. Curry	"	Light prairie	5-6	8-14	100	57	16	2 N	Damaged very much from late seeding, very rusty. Amber, shrunken, dirty.
287	L. O. Miller	"	New brush land	4-25	8-7	104	61	25		Corn and potatos in 1890. Seeded too late, very rusty. Light bright amber inclining to starchy.

FREEBORN COUNTY.

No.	Name of Person.	Town.	Kind of Soil.	Date. Seeded	Date. Ripe	Days Maturing	Weight per bushel	Yield per acre.	Grade	Notes and Remarks.
268	B. C. Aurud	Albert Lea		5-2	8-15	115	57	16	1 N	Corn in 1890. His own Fife wheat was seeded two weeks earlier, had rust and bleached. Weedy, pigeon grass, &c.

FILLMORE COUNTY.

272	E. N. Latks	Hamilton	Meadow timber land	4-22	8-5	105		8	1 N	Damaged very much by chinch bugs. Corn in '90. Bleached and shrunken, weedy.
273	O. J. Halstad	Hurdal	Heavy, deep black loam	5-6	8-16	102	56	20	1 N	Corn and potatos in 1890. Dirty and Somewhat shrunken.

FARIBAULT COUNTY.

283	J. G Pace	Blue Earth C'y	Heavy loam	4-25	8-20	117	61	20	1 N	Flax in '90. Uniform deep light amber.

GOODHUE COUNTY.

261	Gust R Ericson	Goodhue	Pasture breakage	5-5	8-14	101	62	37	1 H	Damaged by rust. Deep amber to starchy.
262	O. E. Samuelson	Vasa	Blk. loam, well manured	4-22	8-3	103	64	30	1 H	Deep b't amber uniform, rusty.

GRANT COUNTY.

254	A. H. Johnson	Hoffman	Light pasture land	4-19	8-10	113	65	20	1 H	Weather too dry; drill; deep amber, uniform.
255	L. Anderson	Norcross	Heavy blk. pra., clay subs.	4-21	8-8	109	63	30	1 H	Heavy deep amber, uniform. Broke in '89. Not as much S. F. needed for seed as B. S.
257	Aug. Jensen	Norcross	Medium heavy prairie	4-21	8-9	110	63	25	1 H	Light bright amber inclining to starchy. No rust on this wheat some on B. S
256	S. J. Beebe	Ashby	Prairie 8 years old	4-27	8-10	105		15	1 H	Would have had double the amount if seeded early. Season too dry. Millet in 1890. Rusty.
379	C. M. Parker	Herman	Light prairie, new	4-28	8-17	111		13	1 N	Light weight. Seeded too late otherwise I would have raised 30 bu. to the acre.
380	B. F. Ellsworth	Elbow Lake	Old prairie	5-2	8-15	105				His B. S. better. Potatos in 1890.

HENNEPIN COUNTY.

249	Wm. Dubson	Min't'ka Mills	Black loam, clay subsoil	4-20	8-7	104	67			L't amber, 60 per cent. starchy; too dry.

HOUSTON COUNTY.

No.	Name of Person.	Town.	Kind of Soil.	Date. Seeded	Date. Ripe	Days Maturing	Weight per bushel	Yield per acre.	Grade	Notes and Remarks.
251	L. A. Tennison		Sandy loam	4.18	8.31	134	59.2	18.2	1 N	Damaged by chinch bugs, weedy. Pot. in '90. Deep amber to starchy, shrunken.

KANDIYOHI COUNTY.

242	G. Van Vorst	Lintonville	Light sandy, new land	4-23	8-8	107	63		1 N	Press drill; 50 per ct. starchy, b't amber.
245	O. N. Grue	Grue	Sandy loam, clay subsoil	4-22	8-11	111				

KANABEC COUNTY.

247	P. O. Peterson	Grass Lake	L't sandy, timber cleared.	4-28	8-14	108	62	20	1 N	Ninety per cent. very starchy.
248	J. H. Stone	Mora	Clay loam, timber cleared.	5-1	8-18	109	59	18	1 N	Fifty per cent. starchy. Corn in 1890.

KITTSON COUNTY.

224	Donald Morrison,	Northcote		4-29	8-24	117	60	32	2 N	Better than average; damaged by frost.
225	J. G. Lindbloom	Hallock	Heavy prairie	4-27	8-19	114	60			Damaged by rain and rust.
	Alex. Gamble	St. Vincent	New breakage	4-23	8-19	118	63			Damaged by hail; 50 per cent. starchy.

LYON COUNTY.

192	Jos. Kenma	Ghent	Prairie broken in 1890	4-23	8-4	103	64	12	1 H	Uniform b't amber. Late seeding cause of small yield.
193	Wm. Marshall	"		4-23	8-3	102	61	24	1 H	Uniform bright amber.
194	O. Decock	"	Medium heavy prairie	4-23	8-14	113	61	28	1 H	Uniform bright amber, some rust on it. Season good.

LINCOLN COUNTY.

197	M. Fowlds	Lake Stacy		4-28	8-24	118					Destroyed by hail.
200	Jas. Hasford	" "		4-28	8-17	111					Sown too late. No good.

LAC QUI PARLE COUNTY.

220	G. L. Labor	Lac Qui Parle		4-28	8-29	123		21			
386	J. E. Gustafson	Nassau	New land, broken in May	4-20	8-4	106	63	20	1	H	Light bright amber, uniform.
	W. G. Smith	Marietta		4-57	8-8	103		20	1	N	Drilled in.

McLEOD COUNTY.

184	David H. Ellis	Hutchinson	Medium prairie	4-22	8-7	107	66	28	1	H	Corn in '90. Uniform deep b't amber.
187	W. F. Higgins	"	New breakage, prairie land	4-28	8-6	100	62	28.2	1	H	The other wheat averaged 22 bu. bleached.

MOWER COUNTY.

153	Thomas Kough	Taopi,	Light sandy loam	4-22	8-13	115	61	17	1	H	Uniform light bright amber. Potatoes in 1890. No rust on this, some on mine.
155	Wm. A. Brown	"	Black loam	4-22	8-12	112	63		1	H	Bright amber, starchy. Earlier B. S. No crop in '90, no rust. Some on farm.
154	Wm. E. Delany	Grand Me'dow		4-25	8-14	111	61	24	1	N	Potatos in '90, slightly rusty; deep amber. Pigeon grass in it.

MEEKER COUNTY.

185	Peter Dille	Bon'ell's Mills	New black loam	5-24	8-12	109	62	33	1	H	Light bright amber, starchy. B. S. went about 30 bushels. Average yield on farm 20 to 25.
	Louis Burgess	Crow River	Sandy soil	4-26	8-5	101		18			Season dry.

MARSHALL COUNTY.

No.	Name of Person.	Town.	Kind of Soil.	Date. Seeded.....	Date. Ripe.....	Days Maturing.....	Weight per bushel.....	Yield per acre.	Grade.....	Notes and Remarks.
159	John Whalen	Stephen	Black loam, clay subsoil...	5-14	9.5	114				
168	J. L. Robertson...	Stephen	Seven year old prairie	4-29	8-26	119		46.2		Potatoes in 1890. Seeded ½ bu. lengthwise and then ½ bu. crosswise.
170	R. A Whitney	Stephen	Light prairie.....	4-23	8-25	124				Millet in 1890.
175	Henry Hoper	Stephen	Heavy prairie.....	4-29	8-29	122		35	1 N	
380	N. J. Engelbratson	Holt.....	Light prairie	5-7	8-27	112		32	1 N	
164	M. A. Beekstrom..	Fohldahl	Light sandy, brush cleared	4-27	8-27	122	30	30	3 N	Badly frosted.
165	Otto Haug.....	Fohldahl	Sandy loam.	4-21	8-27	116			2 N	
	Chas. Tohmer.....	Argyle	.....	4-26	8-25	121				Land too rich, wheat lodged.

OTTERTAIL COUNTY.

126	Jonathan Irish....	Pelican Rapids	Timber land.....	4-22	8-20	120			1 H	Corn and pot. in '90, well pleased with this wheat.
128	J. M. Johnson.....	Pelican Rapids	Timber cleared, old land...	5-5	8-25	112			1 H	Wheat in 1890.
392	R. E. Patterson....	Pelican Rapids	Timber cleared.....	4-22	8-23	123	65		1 H	Potatoes in '90. Light amber, starchy.
427	M. F. Jacobs	Pelican Rapids	Bkg. sandy loam, clay subs	4-24	8-21	119		30		Seeder; no rust on this, some on oats.
127	Hugh Kelly.....	Perham	Meadow, heavy loam	4-28	8-15	109	64	39	1 N	Wheat in '90; 2nd crop, very starchy.
426	J. G. Nelson.....	Parker's Prair	.....	4-20	8-10	112	63	34	1 H	Oats in '90. Drill No rust on this, some on oats.
428	F. N. Gillmore.....	Fergus Falls ..	Heavy clay subsoil.....	4-28	8-16	110			1 H	Barley in '90; best wheat raised for 6 yrs.
123	Ole Hanson.....	Leaf Mount'n	Tim. cleared, blk.clay loam	4-30	8-13	105		31		Broadcast seeder.
124	Geo. W. Chaffer....	Maine.....	Clay loam, brush land	5-5	8-10	97	63	37	1 H	Dark amber, starchy. Best crop for 11 years.
125	J. H. Clark.....	Maine.....	Brush land, sandy loam....	5-5	8-11	98	63	35	1 H	Bright amber, inclining to starchy.
131	John Moore.....	Maine.....	Brush land.....	4-23	8-10	109	64	28	1 N	Wheat in '90, slightly starchy. Looked like frost, due to heat.
132	T. L. Perry & Son	Maine.....	New brush land.....	5-0	8-21	112		30	1 N	Corn in '90.

MORRISON COUNTY.

140	Lorenzo Bernhart	Graceville	Brush cleared in '89, sandy loam.	4-10	8-8	120	.	15		Wheat in 1890.

MURRAY COUNTY.

146	H. G. Day	Slayton	Blk. loam, 3 yrs. old	4-22	8-8	108	63		1	N	A little rust on account of late seeding. Seventy-five per cent. starchy.
150	H. E. Erickson	Hadley	Light loam, clay subsoil	4-23	8-18	117			1	N	Late seeding great draw back.
389	Steven Laible	Iona	New light soil	4-23	8-14	113	62	15	1	H	Season too dry. Deep amber, nearly uniform.
390	Fred D. Hart	Iona	Light soil	4-25	8-16	113	61	17	1	H	Deep amber, starchy. Rust on it and whole farm.

POLK COUNTY.

96	A. St. Michael	Huot	Timber clearing, clay soil	4-21	8-21	122			1	H	
97	Antoine Ray	Huot	Timber clearing, clay soil	4-21	8-22	122			1	N	Damaged by frost.
98	D. B. Ferguson	Mallory	Heavy prairie	5-2	8-17	107		25	1	N	Millet in 1890. Damaged by rust.
393	Wm. Flemming	Mallory	Garden land, black loam	4-25	8-6	103		30			Some rust.
99	Peter Martell	Gentilly	Blk. heavy loam—prairie	5-14	8-31	109					No rust on this, other grain rusted badly.
107	Chr. Hagen	Fosston	L't timb. clear. clay subs	4-29	8-11	104	63	35			Rust on this wheat, little on his own, much on oats.
108	J. F. Uteck	Fosston	Brush breakage	4-21	8-20	121	62	26	1	N	
109	I. S. Erickson	Fosston	Dark loam, clay subsoil	4-28	8-27	121					Rust on this; none on oats.
111	Lyman Clarke	St. Hilaire	Light prairie	4-24	8-24	124					Damaged by frost.
87	J. K. Pederson	Carman	Heavy prairie	5-2	8-25	115					Potatos in 1890.
88	W. N. Gonfray	Maple Bay	New brush land	5-5	8-24	111					
398	P. W. Horton	Maple Bay	Light new prairie	4-27	8-11	106		20	1	H	His B. S. only went 16.2 to the acre.
94	Chas. Rejembal	Crookston	Old pasture land	4-23	8-19	118	62	28	1	H	Amber, inclining to starchy, slightly shrunken.
103	Fabien Rejembal	Crookston	Blk. sandy loam, new bkg.	4-22	8-25	125	61	33	1	N	Deep amber, shrunken.
104	L. Davis	Crookston	Heavy prairie, low	4-27	8-31	126	59.2	25	R		Musty and starchy. Rejected.
106	J. P. Bullaw	Crookston	New heavy prairie	4-23	8-17	116		23	1	H	
112	Hugh Galbraith	Crookston	Prairie land	4-26	8-20	116	62		1	H	Deep amber, uniform.
397	L. H. Judson			4-27	8-24	119					Shoe drill, not better than his own.

POPE COUNTY.

85	Olans Peterson	Langhei	New land, clay subsoil	4-27	8-8	103	65	15	1	H	Corn in 1890.

REDWOOD COUNTY.

No.	Name of Person.	Town.	Kind of Soil.	Date. Seeded	Date. Ripe	Days Maturing	Weight per bushel	Yield per acre.	Grade	Notes and Remarks.
73	W. C. Mann	N. Redwood	L't sandy loam, new bkg.	4-21	8-6	107		20		Corn in 1890. Press drill.
75	A. D. Stewart	N. Redwood		4-27						Seeded too late. Crop no good.
77	F. M. Shumacher,	N. Redwood	Sandy loam, bottom land	4-30	8-10	102	62	28	1 H	Corn in '90. Shoe drill, amber deep, uniform.
76	J. W. Marion	Lamberton	Timothy sod	4-27	8-22	117		20		

RICE COUNTY.

59	C. O. Persons	Lester	Rich timb. land, clay subs.	4-20	8-11	113	63	14	1 N	Pot. in '90, l't amber, somewhat starchy
60	C. L. Clover	Dundas	Timber land, heavy	4-23	8-7	106	61	14	1 H	His own went 20 bushels to the acre.
61	N. Becker	Faribault	Low timber land	4-29	8-7	100	62	30	1 H	Bright amber, uniform.
436	Daniel Dillen	Faribault	Low timber land	4-30	8-10	102	61	24	1 H	Deep amber, uniform, somewhat shrunk.
40	Jas. McCaln	Hazelwood	Low timber land	4-22	8-5	105	62	14.2	1 N	Damaged by chinch bugs, oats in '90, b't amber, slightly starchy.

RENVILLE COUNTY.

63	H. H. Olson	Sacred Heart	Heavy, low prairie	4-23	8-11	110	62	20	1 H	Corn in '90, bright amber.
64	C. H. Hopkins	Fairfax	New bkg. sandy loam land	4-20	8-31	133				
67	James Drake	Fairfax	New land	4-20	8-5	107			1 H	Corn in '90. Broadcast seeder, b't amber.
68	Alf. Johnson	Olivia	Light soil, one year old	4-23	8-8	107				Seeded too late, otherwise very good.
69	B. C. McEwen	Buffalo Lake	Heavy prairie, loam.	4-27	8.13	108	61	25	1 H	Choice; very much pleased with it. Flax in '90, b't amber, some starchy.
399	S. C. Dike	Norfolk	black loam, clay subsoil	4-23	8-27	126	62	25	1 H	Bright amber with caps.
400	I. S. Sheppard	Lakeside	Deep, old land	4-25	8-9	106	61	12	1 H	Bright amber, some starchy.

SCOTT COUNTY.

404	A. R. Snow	Prior's Lake	New land, light loam	4-22			59	25	2 N	Corn in '90, musty, 75 per cent. starchy.

SWIFT COUNTY.

32	Wilcox & Liggett.	Benson	Loam, clay subs, prairie...	4-23	8-7	106	65				Drill, bright amber, uniform.
34	N. W. Simon	Benson	Med. l't prairie, new land	4-21	8-12	113	62			1 H	Seeder.
35	J. M. Simon	Benson	" " " " "	4-27	8-12	107	63	16		1 H	Damaged by rust, l't amber, little starchy.
38	W. F. Wilcox	Benson	Sandy loam, clay subsoil..	4-18	8-10	114	63	24		1 H	Corn in '90, new bkge. l't amber, starchy. Potatos in 1890.
409	Ed. Layland	Benson	Heavy blk. loam new pra.	4-27	8-9	104					
36	Ole E. Hegstad	Hegbert	New land, clay subsoil	5-6	8-22	108				1 H	Flax in 1890, press drill, poor on account of late seeding.
37	J. M. Ellingson	Halloway					65			1 H	Deep amber, some starchy.
45	D. W. Swingle	Appleton	Old light soil	4-24	8-6	104	60	28			Raised wheat for three years.

STEARNS COUNTY.

407	Wm. Shuffins	Sauk Centre...	Sandy prairie, 1 yr. old	4-23	8-15	114		21			Press drill.
437	R. A. McCoy	Kimball	Heavy blk. loam, tim.land				62	24		1 N	Light amber, starchy.

SHERBURNE COUNTY.

406	James Glipp	Lake Fremont	Sandy loam	4-28	8-7	101		15			
438	Chas. Bridge	Lake Fremont	New land		8-12		61	30		1 N	Fifty per cent. starchy. Good wheat for this country.

STEELE COUNTY.

49	J. S. Cory	Medford	Light prairie	4-24	8-7	105				1 N	Damaged by rust and blight.

TODD COUNTY.

377	O. L. Graves	Nebo	Heavy loam, brush prarie	5-1	8-18	109	61	24		1 N	Deep b't amber to starchy. Shrunken. A little rust.

TRAVERSE COUNTY.

29	Byron Wilcox	Wheaton	Heavy prairie	5-1	8-27	118		10			Injured by frost.

WABASHA COUNTY.

No.	Name of Person.	Town.	Kind of Soil.	Date. Seeded	Date. Ripe	Days Maturing	Weight per bushel	Yield per acre.	Grade	Notes and Remarks.
25	O. E. Boughton	Mazeppa	Clay loam, prairie	4-29	8-10	103	61	19	1 H	Seeded 14 days late, drill, ⅓ better than my own.
27	James Hayes	Millville	Heavy grub land	5-4	8-16	104	61	15	1 H	Deep amber, some grains shrunken, corn in '90, considerable rust on it.
28	J. E. Chasrey	Wabasha	Clay, black, sandy	4-27	8-6	101	64	48	1 N	75 per cent. starchy, straw stiffer, stands wind better.
39	F. H. Floguson	Elgin		4-23			61		1 N	Corn in '89, somewhat shrunken, broadcast, deep amber.

WASHINGTON COUNTY.

434	Peter Thompson	Cottage Grove	Black loam	4-30	8-17	109	62		1 H	Uniform bright amber, ripened ten days earlier than B. S.

WADENA COUNTY.

24	Theo. Lukins	Verndale	Old prairie land	4-27	8-14	109	63	17	1 N	Millet in '90, uniform bright amber, seeded too late.
410	C. A. Alton	Lukins	Brush prairie	5-12	8-24	104	60	22	2 N	
411	Peter Aunt	Wadena					62		2 N	90 per cent. starchy

WILKIN COUNTY.

12	A. W. Morris	Tenney	New land, heavy prairie	4-24	8-10	108	63.5	18	1 H	Broadcast seeder, season too dry, amber, large grain,
13	Jos. Fredericks	Kent		4-22	8-17	117	62	34.3	1 H	Dark amber, large grain, better than B. S.
14	J. B. Rodenmacher	Kent		4-22	8-9	109	63		1 H	
15	J. R. Harris	Kent	New land	5-13	8-6	90	64	21.5	1 H	Drill, amber, large grain.

WINONA COUNTY.

8	Gouston Melcher..	Mt: Vernon ...	.....				64		1	N	Potatoes in '90, broadc. seeder, starchy.
10	S. Garden	Homer.....	Oak clearing.....	4-28	8-7	101	60	10	2	N	Very starchy, potatos in '90.

WRIGHT COUNTY.

3	W. F. Shattuck....	Clearwater	Black loam, river bottom	4-22	8-8	108	61		1	N	Broadcast seeder, 25 per cent slightly starchy.
424	W. T. Brannan.....	Clearwater	Light, sandy prairie.....	4-24	8-7	106	58	11	1	H	Amber, somewhat shrunken, corn in '90, damaged by drouth.
4	Aaron Reinmuth..	Howard Lake	New breakage	4-26	8-15	111					Cleared of oak, corn in '90.
5	F. T. Prohe	Howard Lake	New breakage	4-29	8-24	117	63	35	1	N	Very little starchy, oak clearing, corn '90.
413	Wm. Fleming	.....	.....				63		1	N	Corn in '89 and '90, 50 per cent. starchy.
6	H. A. Niles.....	Hasty	New land, light sandy	4.25	8-13	108	64	18	1	N	75 per cent. starchy.
7	Levi Drew.....	Hasty	Timber land	4-22	8-9	109	61	18	1	H	Corn and potatos in '90.

SUMMARY OF RESULTS.

	Number.	Per cent.
Total reports tabulated	169	
Total number reporting rust	14	
Total number injured by frost	4	
Total number with reports on weight per bushel	119	
Total number weighing 64 pounds or over per bushel	16	15
Total number weighing 63 pounds per bushel	26	24
Total number weighing 62 pounds per bushel	24	22
Total number weighing 61 pounds per bushel	23	21
Total number weighing 60 pounds per bushel	9	8.2
Total number weighing 59 pounds or less per bushel	11	11
Total number yielding 40 bushels per acre and over	6	5
Total number yielding from 35 to 40 bushels per acre	10	12
Total number yielding from 30 to 35 bushels per acre	19	16
Total number yielding from 25 to 30 bushels per acre	17	10
Total number yielding from 20 to 25 bushels per acre	27	
Total number yielding from 17 to 20 bushels per acre	13	
Total number yielding under 17 bushels per acre	26	

Shortest time for maturing, 90 days; longest, 118 days.

Average yield per acre, 24.1 bushels.

Average weight per bushel, 62 pounds.

Average of days maturing, 106.

In conclusion little remains to be said that is not already recorded in the tables or summary.

The use of good seed wheat, of uniform sized grains, free from foreign matters or other varieties of wheat, when not hampered by rust, dry weather, frost, or insects, results in uniformity in the time of maturing of the crop, a large average yield per acre, and a high average weight per bushel.

PRELIMINARY REPORT UPON AN INSECT INJURIOUS TO WHEAT.

OTTO LUGGER.

This report, though very incomplete in all details, is made at this time to warn farmers against an insect not observed before in Minnesota, and to enable them to prevent more serious losses in 1893. As soon as the life-history of this insect has been studied more thoroughly it will be given in a future bulletin.

During the early part of September a number of letters were received from different parts of the Red River Valley, both from the Minnesota and North Dakota side, in which the writers complained about an insect of some kind that had reduced the wheat crop very materially by partially cutting off the culm (stem) just above a joint from three to four inches above the ground. This took place at a time when the head was filling. The culm above the injured joint wilted, gradually turned yellow, and soon after broke down entirely by bending over at the infested spot. Some of the writers discovered that the injury was caused by an insect of some kind, while many others, less observant, claimed that the injury was due to hail, to a blistering hot sun, or to some other cause. Two gentlemen specially interested in this insect, and fearing greater trouble for next year, invited the entomologist of this station to make an investigation and to suggest remedies. The farm of Mr. Chas. T. Ohmer, of Argyle, Marshall county, was visited first. In one of his fields, from which the crop had been harvested and removed, very many heads of wheat were found upon the ground. The supporting culms had been broken down before harvest, and were consequently not cut by the reaper. These heads were all partly filled with berries more or less badly shrunken, and the culms were still adhering to the roots. The break-

age of the culms had taken place most frequently above a node or joint about three inches from the ground. Just below this breakage, and immediately above the joint, the culprits were found. In most cases but one puparium, but in a few cases two, three, and even more puparia could be found. A puparium is the hardened skin of the larva or worm, made strong by a deposit of horny material. These puparia are glossy chestnut-brown, shading to a yellowish-brown towards the smaller end; faint indication of sutures or segments are visible. All these seed-like objects contained at that time the larvæ or worms which are of a white color. No pupæ could be detected during the investigation, nor can they be found at this date (Sept. 28). Larvæ could not, as a matter of course, exist in such dry culms. These puparia are very similar to those of the Hessian fly, or to the "flax seed stage" of that insect, and this resemblance had given color to the belief of some that this injurious insect had found a home in the valley. It seems, therefore, most likely that the insect investigated hibernates in this stage, and that the puparia are really well protected in this condition, and in the position assumed inside the culm. They are inserted in the material of the upper part of the node, inaccessible by any moisture from the outside, as the culm above does not break off entirely but simply bends in a more or less acute angle a short distance over the puparia, and thus prevents the entrance of moisture. Yet the culm is sufficiently fractured to permit a free exit of the future fly in spring.

A number of other places were visited in the adjoining counties of Polk and Kittson, and it was found that similar conditions prevailed in many fields. In fact the numerous inquiries among farmers plainly indicated that this insect has caused more or less damage over a large area, and that remedies should be applied wherever necessary.

It is not always easy or even possible to explain why any one insect should suddenly appear in such numbers over a large area. It is only by a very careful and long continued investigation that we may sometimes arrive at a true explanation. Here it is readily found in the fact that owing to the wet autumn of 1891, and the equally wet spring of 1892, not

much more than one half of the usual acreage of wheat was plowed, and in many places the shocks of grain had to be left upon the fields. Many inquiries also plainly indicated that small patches of wheat had been noticed in 1891 which showed bleached heads long before harvest, and no doubt these white culms harbored the insect unknown to anyone. Since the culms infested with these puparia were left upon the fields the resulting winged insects were not destroyed, but they issued during the spring of 1892 and greatly extended their domain. The very causes that killed off the armies of young migratory locusts, *i. e.* excessive moisture, protected this new pest.

From all appearances this insect is one of the Frit flies, but which one, remains to be seen by breeding it to maturity. The name Frit fly was given this insect from the fact that Swedish farmers call the worthless grain resulting from injuries caused by such flies "frits."

From the rather few facts we at present possess in regard to this insect in Minnesota one very important conclusion may be reached. As the insects hibernate in the culms of wheat in stubble fields, and very likely remain in that condition until spring, simple remedies are evident and can readily be applied. All that is necessary to kill the great majority of these insects is to destroy the stubble at this time of the year, or as soon as possible. Two methods are feasible: burning the stubble, or plowing it under. Burning can be practiced in some few cases but in many fields there is not sufficient material to do it thoroughly. Plowing therefore, is our best remedy, and no field should be left unplowed that contains such insects, or is suspected of containing them. A very superficial inspection of the fields will show the whereabouts of these insects, if the owner has not already detected the broken culms or heads. By splitting with a knife the joint just below the broken culm the dark puparium will be readily seen. If not the discolored interior of the culm above will indicate its presence, and closer inspection will reveal the culprit. All such fields that contain infested straw should be plowed, and this as soon as possible to make sure; the rest of the fields can be plowed later. In doing

this now we will be sure of one thing: the insects although well protected against moisture will come in lasting contact with the moist soil, the broken tube above will be filled with earth, and the fly can not escape next spring to carry destruction near and far.

The damage caused by this insect in 1892 is by no means a small one. In many places fully one fourth of the entire crop of wheat has been destroyed, and in a great many more the losses amount to at least one tenth. As many places are badly infested the total amount is quite large, and if no steps are taken to prevent it, a repetition may become ruinously large in 1893.

UNIVERSITY OF MINNESOTA.

Agricultural Experiment Station.

BULLETIN No. 24.

HORTICULTURAL DIVISION.

OCTOBER, 1892.

ORNAMENTAL AND TIMBER TREES, SHRUBS AND HERBACEOUS PLANTS IN MINNESOTA.

NOTES ON THEIR HARDINESS AND DESIRABILITY.

☞ The Bulletins of this Station are mailed free to all residents of the State who make application for them.

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.

University of Minnesota.

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*INTRODUCTION.

The object of this bulletin is to furnish reliable information to the planters of ornamental and timber trees, shrubs, herbaceous plants, etc., in Minnesota; to encourage the growing by nurserymen of a number of desirable plants adapted to our conditions that are not generally known, and as an answer to the many requests received for information in regard to the proper plants to use for park, street and lawn planting in this state. The work is of a practical nature and is intended chiefly as a criticism of those trees and plants met with in the catalogues of our most progressive nurserymen. Nearly one hundred species and varieties now growing on the experiment station grounds are not mentioned as they either have not been grown here long enough to warrant us in drawing conclusions as to their value or are chiefly of interest to botanists.

In connection with the notes on hardiness, it should be borne in mind that there is a great variation in the types of different plants, and that the hardiest form is always referred to, where two types are known. For instance, the northern or native red cedar is perfectly hardy anywhere in this state, while the form grown in the southern, central and eastern states is not nearly so hardy and is not a safe tree to plant. Nearly the same may be said of black walnut, butternut, sugar maple, box elder and to a great degree of many other plants. It is well, then, for planters to select, as far as practicable, plants grown in this state or those grown in northern nurseries from northern stock. In the table on hardiness the native plants are starred and they will generally be found most satisfactory. Where the Rocky Mountain conifers are referred to, the form meant is that from seed grown on the eastern slopes and foot hills of the Rocky Mountains. Plants from the western slopes and ranges have been conclusively shown to be more

*A table of contents and an index will be found at the end of this bulletin.

easily injured by dry winds and cold weather than those of the same species from the eastern slopes, and they are not, therefore so well fitted to this state.

In the preparation of this bulletin, I have had the kind assistance and advice of many planters and nurserymen in various parts of the state and their services are hereby gratefully acknowledged. I am under especial obligations to Hon. Wyman Elliott and R. J. Mendenhall of Minneapolis, Hon. S. M. Emery and J. M. Underwood of Lake City, Hon. L. R. Moyer of Montevideo, Prof. C. B. Waldron of Fargo, N. D., G. W. Fuller of Litchfield, J. S. Harris of La Crescent and E. H. S. Dartt of Owatonna for much assistance in preparing the table of hardiness, and by their suggestions and help in many ways.

In making up the table of hardiness I have endeavored to take notes from as many characteristic and widely separated parts of the state as practicable, and from well known, representative men. The notes by Hon. Wyman Elliott are selected because he is widely and favorably known among horticulturists as one who has had much experience in planting trees himself and in observing the plantings made by others in Hennepin and Ramsey counties and vicinity.

Hon. L. R. Moyer's notes are made from his experience at Montevideo, Chippewa county, which is thoroughly representative of the severe conditions of our western prairies of the central portion of the state.

The notes by J. S. Harris are given with reference to the hardiness of plants in south eastern Minnesota, where he has made his home for many years and where he has earnestly watched and worked for the development of horticulture in all its branches.

Prof. C. B. Waldron is professor of arboriculture in the North Dakota Agricultural College, and his notes are given from the standpoint of his experience at Fargo and at Duluth.

E. H. S. Dartt is superintendent of the state tree station at Owatonna. His notes are given with reference to his experience in that section.

SAMUEL B. GREEN,
PROFESSOR OF HORTICULTURE,
Oct. 3d, 1892. University of Minnesota.

DECIDUOUS TREES.

ACER. Maple.

*WHITE, SILVER LEAFED OR SOFT MAPLE. (*A. dasycarpum.*)—Very hardy, easily transplanted and of rapid growth, but suffers much from a deficiency of moisture in the soil. It is especially desirable for somewhat protected locations. If exposed to severe winds the limbs are often broken in the crotches, but this difficulty may be largely overcome by occasionally shortening in the branches and retaining as much as possible a central leading shoot. In many parts of the state it is a good street tree, and valued for wind breaks on account of its quick, upright growth. Easily grown from its seed which ripens in June.

CUT LEAFED OR WIER'S CUT LEAFED MAPLE. (*A. dasycarpum, var. Wierii.*)—This is a sport from the white maple and is propagated by budding or grafting on the same. I think it generally not nearly as hardy as the white maple. A pretty, small, lawn or park tree of irregular pendulous habit and finely cut foliage. Desirable for sheltered locations.

*SUGAR, HARD OR ROCK MAPLE. (*A. saccharinum.*)—Very hardy over most of the state, in heavy, rich lands, when grown in forests, and forming one of our most valuable timber and fuel woods. It does well in the southern and south-eastern parts of the state when grown as a street or lawn tree if the trunk is shaded with straw or other material. When not thus protected the trunk is liable to sun scald. In the northern and western half of the state it winter kills badly in exposed locations, especially when young and before becoming well established. Grown from seed which ripens in autumn.

NORWAY MAPLE. (*A. platanoides.*)—A large tree from Europe, with large, dark green leaves, which are smooth and green on both sides. In milder sections this is a desirable street tree, rivaling the hard maple in value, but we have found it too uncertain here to be recommended for general planting, though it has stood fairly well for seven years at the experiment station.

SCHWEDLER MAPLE. (*A, platanoides, var. Schwedlerii.*) —A variety of the Norway maple, with a most beautiful crimson color to its young growth, which changes to a rich brown when mature. Very handsome and showy in the spring, and worth growing in a small way. Propagated by budding or grafting on the Norway maple, or by layering.

RITTENBACH MAPLE. (*A. platanoides, var. Rittenbachii.*) —A variety with bronze purple color to the foliage in the latter part of the season. A beautiful variety, worth growing in a small way. Propagated by the same means as the Schwedler maple.

*RED, SWAMP OR SOFT MAPLE. (*A. rubrum.*)—A native tree of medium size and rather slow growth, with deep red blossoms early in the spring, and brilliant scarlet foliage early in autumn. Grown from seed which ripens in June. It is not often successfully cultivated here as a street or ornamental tree.

TARTARIAN MAPLE. (*A. Tartaricum.*)—A small, pretty tree of very promising hardiness, not long tried here. Grown from seed which ripens in autumn.

ÆSCULUS. Horse Chestnut.

HORSE CHESTNUT. (*Æ. Hippocastanum.*)—This is unreliable, but in sheltered locations on heavy soil will often last several years. Not hardy at the experiment station.

ALNUS. Alder.

EUROPEAN ALDER. (*Alnus incana.*)—A small, pretty tree that can often be used to advantage in ornamental planting. Grown from seed which ripens in early autumn.

BETULA. Birch.

*CANOE, SILVER OR WHITE BIRCH. (*B. papyracea.*)-This makes a beautiful lawn and park tree and is not nearly as

much planted as it should be. It is conspicuous and pretty in both summer and winter, affording a very pleasing contrast with thedark foliage of other trees, and especially so when contrasted with evergreens in winter. Best adapted to moist soil, but will hold on well even in dry situations. Grown from seed which ripens in autumn.

White or Poplar Leafed Birch. (*B. alba, var. populifolia.*)—Indigenous to the eastern states and generally found on poor soil. It differs from the above in having many black twigs, pendulous shiny leaves, and in not attaining to large size. Not nearly as desirable as the next, which it somewhat resembles. Propagated by seed which ripens in autumn.

European White Birch. (*B. alba.*)—A pretty, symmetrical tree of medium size, with white bark and of rapid growth while young. Very desirable for ornamental purposes. Easily propagated by seed which ripens in autumn. The variations are grown by budding, grafting, and inarching on the species.

Cut Leafed Weeping Birch. (*B. alba, var. laciniata pendula.*)—A variety of European white birch. Probably the most popular lawn and park tree. Hardy in good soil anywhere. In very dry situations short lived. Very desirable wherever it can be grown.

Purple Leafed Birch. (*B. alba, var. purpurea.*)—A variety of the European white birch with foliage and young bark purplish in color and in pleasant contrast with the white bark of the older growth; conspicuous and pretty.

*Yellow or Gray Birch. (*B. lutea.*) A pretty, desirable native tree of rather slow growth. Propagated by seed which ripens in autumn.

CARYA. Hickory.

* Bitternut Hickory. (*C. amara.*)— Valuable for hoop-poles and it can often be profitably planted on rich land. It grows very fast until it commences to fruit, and makes a pretty lawn or park tree. Readily distinguished by its orange yellow winter buds and very bitter nut. This species is indigeneous to the central and southern

portions of the state. Probably the hardiest and best form of hickory for general planting here. It does not make as large a tree as the pig nut or the shell bark hickory, but grows faster when young. Easily grown from seed which ripens in autumn.

CELTIS. Hackberry.

*Hackberry. (*C. occidentalis.*) One of the most beautiful street or lawn trees that we have. Found frequently in the forests in the south half of the state and occasionally elsewhere. In dry situations it is not so hardy as the white elm which it rivals for ornamental planting. Very desirable. Propagated by seed which ripens in autumn.

CATALPA.

Hardy Catalpa. (*C. speciosa.*) Very unreliable at the experiment station, and I think not valuable for timber in any part of the state. In some sheltered locations the trees may last a few years and produce their beautiful flowers, but are often killed back and sprout from the root. A few are worth trying in such places for ornamental purposes. Flowers in large panicles in July. Grown from seed which ripens in autumn Plants from northern grown seeds are hardiest.

CRATÆGUS. Thorn.

*White Thorn. (*C. coccinea.*) A pretty and desirable small native tree or shrub with an abundance of white flowers in spring, followed by bright red fruit. Especially desirable for moist, rich soil. Grown from seed which ripens in autumn.

*Cock-Spur Thorn or Thorn Apple. (*C. Crus-galli.*)—A native species with very long thorns and straggling habit. White flowers in spring, followed by dull red fruit. A handsome, desirable tree.

ELÆAGNUS. Oil Berry.

(*E. augustifolia.*) A very pretty round topped tree of medium size, light green, downy foliage and dark colored bark. Introduced into this state by the Mennonites and by them esteemed very valuable for screens, etc. It is hardy in the

southern half of this state and generally desirable, though further north it occasionally slightly winter kills when young and in exposed situations. Pretty and desirable. Easily grown from seed.

GLEDITSCHIA.

HONEY OR THREE-THORNED LOCUST. (*G. tricanthos.*) —Not hardy at the experiment station.

FRAXINUS. Ash.

*WHITE ASH. (*F. Americana.*) A well known native timber tree of much value, attaining a large size. It makes a good street tree in some locations, but is rather stiff in outline. Valuable for forest planting, except on our western prairies, where it is not very hardy. A much more rapid grower than the next. Propagated by seed, which ripens in autumn.

*GREEN ASH. (*F. viridis.*)—Somewhat resembling the above but smaller, and far less valuable for timber, though much more hardy. It grows very fast when young, and before it produces seed, after which its growth is rather slow, and it never attains a large size. The seed of this species being readily obtained, it is frequently substituted for that of the white ash which is not so abundant, and is quite different in form. Propagated by seeds which ripen in autumn. Probably all the ash in the western part of the state is of this kind.

*BLACK OR SWAMP ASH. (*F. sambucifolia.*)—Found in wet places. A small tree used for coarse baskets, hoop poles, etc. The bruised foliage exhales the odor of elder. Not valuable for tree planting.

GYMNOCLADUS.

*KENTUKY COFFEE TREE. (*G. Canadensis.*)—A pretty and conspicuous tree with very large, compound leaves. (They are often 2 feet long.) Found sparingly in the southern part of this state. It can be occasionally planted in sheltered locations to advantage. Grown from seed which ripens in early autumn.

JUGLANS. Walnut.

*BLACK WALNUT. (*J. nigra.*)—Unreliable except in south-

ern Minnesota, where in places large trees were abundant when the country was first settled. It can now be planted to advantage for timber in sheltered locations, especially upon rich heavy soil in southern Minnesota. Not reliable as an ornamental tree. It succeeds best when grown from seed raised in this state or northern Iowa. Seed ripens in autumn.

*Butternut. (*J. cinerea.*)—A pretty, large native tree that resembles the black walnut in foliage and habit but is much hardier, and the nut is more valuable for eating. It succeeds best in rich, heavy soils. In some parts of the state a satisfactory ornamental tree. Propagated by seed which ripens in autumn.

LARIX. Tamarack.

*American Larch or Tamarack. (*L. Americana.*)—A pretty, native tree, found throughout the eastern and northern parts of the state in swamps. Not as desirable as the next. Grown from seed which ripens in autumn.

European Larch. (*L. Europea.*)—This tree has rather disappointed the expectations of tree planters in not being as long lived or as desirable for timber as was expected. It is, however, of a more regular and close habit than our native species, and is far more desirable for ornamental purposes. It is a rapid grower when young and is very valuable for occasional use in ornamental planting to give variety to the landscape. Propagated by seed which ripens in autumn.

MORUS. Mulberry.

Russian Mulberry. (*M. Tartarica.*)—The most contradictory evidence is plentiful regarding this tree, and too much has often been claimed for it, but the following is what I have gathered from many observations: In the southwestern part of the state it is regarded with high favor as a low wind-break. The trees are hardy and form a close growth; they fruit abundantly but the berries are insipid though often of good size. At the experiment station the new wood has frequently been entirely winter killed, but it quickly outgrows any damages of this sort and makes a vigorous, pretty wind-break. For a low wind-break to protect small fruit,

or trees on tree claims it is very valuable in the southern one-third of the state. As a timber tree I think it almost worthless. For fruit it should be grown from cuttings of the the best plants. It should be borne in mind that the plants generally sold are from seed and that scarcely two seedling plants will bear fruit exactly alike and they vary very much in both foliage and fruit. It is bi-sexual and consequently it is necessary to have both kinds of plants, in order to obtain fruit. Of very rapid growth. Grown from seed, cuttings or layers.

NEGUNDO. Box Elder.

*Box Elder or Ash Leafed Maple. (*N. aceroides.*)—Too well known to need much notice here. In good soil in protected locations in the southern half of the state it makes a good sized tree, but at the extreme north and in very exposed or barren situations anywhere, it becomes much dwarfed. At Fargo, N. D., it is popular as a street tree. A fairly good street tree in favorable locations, but rather small for best results. Of clean habit, long lived and of wonderful hardiness where the soil is not very dry. A valuable pioneer tree. Of very rapid growth when young. Grown from seed which ripens in autumn.

OSTRYA.

*Ironwood, Hop-Hornbeam, American Hop-Hornbeam or Lever-Wood. (*O. Virginica.*)—A pretty, native tree of medium size that does well under cultivation. Generally hardy but it prefers some protection and does best in moist, rich land. Grown from seed which ripens in autumn.

POPULUS. Poplar.

Silver, White or Abele Poplar or Abel-Tree. (*P. alba.*)—Of rapid growth and rather irregular habit, perfectly hardy anywhere. The downy whiteness of the under side of the leaves and the white bark make it a tree that can often be used to enliven groups of trees of more somber aspect. The wood is fine grained and valuable for fine finishing work. The great objection to it as a street or lawn tree is that it sprouts a good deal from the roots, especially if they are broken. This is, however, no objection to it as a forest tree,

for which it is very desirable, as it makes valuable timber. Propagated by sprouts and cuttings. Desirable. There are several varieties of this, and among the best are the following:

Bolleana Poplar. (*P. alba, var. Bolleana.*)—The foliage of this variety is much prettier than that of its parent. In habit it is upright and close like the Lombardy poplar, though unlike this latter tree it promises to be long lived and very useful and beautiful for ornamental planting. It is not so easily propagated as the Abele, as it does not sprout or root easily from spring made cuttings. However, cuttings of it made in the autumn and well calloused before planting out, I think as sure as Concord grapes so treated. Hardy.

(*P. alba, var. nivea argentea.*)—A form of the Abele with a much more silvery aspect on account of the greater amount of down on the leaves and young growth. Very pretty for contrasting with other trees. Propagated by cutting and sprouts.

Lombardy Poplar. (*P. fastigiata.*)—Conspicuous for its erect, close, columnar form. It can often be used in a small way to advantage in ornamental planting, to secure variety. A very rapid grower. Hardy when young. In sheltered positions it stands fairly well but generally as soon as it gets to be of much size, it begins to die in the top and becomes unsightly. Not desirable for extensive planting. We have a form of this, from Russia, which Prof. Budd reports as far more desirable, but as we have had it only eight years and during that time neither it nor the common form have been injured, we are not warranted in drawing conclusions. Easily grown from cuttings.

Cottonwood. (*P. monilifera.*) This is well known and very popular as a rapid growing, pioneer tree. It succeeds admirably on the prairies of western Minnesota, but is of little value except as a wind-break, being quite worthless as lumber and for farm purposes. With it should be planted some more durable and better kind to take its place, as it generally reaches maturity in about twenty years or less

and then commences to fail rapidly. A not clearly defined form of this with yellow heart wood and perhaps larger leaved, called yellow cottonwood, found in the Missouri valley, is far better for general planting, since it affords timber that for many purposes will compare favorably with white pine. This form should supercede the common or native cottonwood for general planting. Grown from cuttings or from seed which ripens in early autumn.

Many complain of the cottonwood being a nuisance on account of the cottony float which it sheds with its seed. This tree is diœcious, that is, there are male and female trees of it. If only male trees were set, or cuttings of male trees—those with reddish tassles—no cotton would be produced.

Van Gert's Golden Poplar. (*P. monilifera, var. Van Gertii.*) A form of the cottonwood that has conspicuous golden green leaves all summer. Desirable for occasional use in ornamental planting to secure pleasing contrasts. Very useful for parks. Of much the same habit as the cottonwood; healthy and a strong grower. Easily increased by cuttings.

Russian or Asiatic Poplars.—We have in our collection at the experiment station, ten kinds of these poplars which we have grown seven years. (For a detailed report on them see Bulletin No. 9.) Several of them give promise of being desirable trees for general use, while others have their foliage too much injured by fungi, are too susceptible to the attacks of the poplar borer, (*Saperba concola*) or are of too slow growth to ever become valuable. Those most desirable are the following:

Populus certinensis. A fast growing poplar with oval-pointed leaves. It makes a large tree. Of rather closer and better habit than the cottonwood. I think far more desirable than the common cottonwood for ornamental and timber planting, but it has not been tried sufficiently in Minnesota to warrant very pronounced opinions regarding it. Easily grown from cuttings.

Populus Petrouski. As we have it, apparently indentical with the certinensis.

Laurel Leaved Poplar. (*Populus balsamifera, var. laurifolia.*) This is a little slower grower than the *P. certinensis.* The foliage is very thick and healthy and white on the under side. Distinct and desirable and well worthy of trial. Of rapid growth. It roots easily from cuttings.

Populus balsamifera, var. Siberica pyramidalis.—A pretty, ornamental and timber poplar with stiff, leathery foliage somewhat resembling that of the laurifolia. Hardy and desirable. Grown from cuttings.

Populus Wobsky. A poplar of peculiar aspect and resembling a cherry tree in foliage. At the experiment station rather more liable to attacks of the poplar borer and to leaf fungi than most of the other kinds, but reports from Chippewa county show that it is doing well there. A rapid grower. It roots easily from cuttings.

Birch Leaved Poplar. (*Populus betulifolia.*)—Not especially valuable, but a fast growing poplar, with leaves shaped much like those of the cottonwood but broader. It might be used to give variety to timber borders. Easily grown from cuttings.

PRUNUS. Cherry.

*Wild Black Cherry. (*P. serotina.*)—A native tree, very pretty at all times and especially so when in blossom or when loaded with ripe fruit. Very hardy when grouped among other trees, but it occasionally sun scalds when standing alone. Valuable as an ornamental tree and for timber planting. It yields, next to black walnut, the most valuable wood grown in this state. Flowers in June. Grown from seed which ripens in autumn.

*Wild Red Cherry. (*P. Pennsylvania.*)—A small native tree of good form and habit, that does well under cultivation. White flowers in May. Grown from sprouts and root cuttings or from seed which ripens in autumn.

*Choke Cherry. (*P. Virginica.*)—A small native tree that does well under cultivation. White flowers in May. Grown from sprouts or from seed which ripens in autumn.

PYRUS.

*Wild Crab. (*P. coronaria.*)—This may sometime be used to advantage as a lawn tree, but it is generally unsatisfactory, and is very liable to blight. Flowers in May. Increased by root grafting.

*American Mountain Ash. (*P. Americana.*) This is a pretty, hardy native tree of coarse growth and larger, lighter colored berries than the European species. I think it somewhat hardier. Propagated by seed which ripens in autumn.

European Mountain Ash. (*P. aucuparia.*)—A valuable and popular tree; very ornamental in flower and fruit. Propagated by seed. Rather hardier than the Duchess apple. It is holding on exceedingly well in the vicinity of St. Paul and at Fargo, N. D., but is somewhat liable to sun scald and blights occasionally. Very hardy when established. Grown from seed which ripens in autumn.

Weeping Mountain Ash. (*P. aucuparia, var.*)—This is a very hardy pendulous form of the European mountain ash, and makes a conspicuous tree on the lawn. It generally requires some pruning when young to make it fall evenly around its stem. Propagated by budding and grafting on the species.

QUERCUS. Oak.

The oaks are slow growers, but long lived. Our best growing species is the burr oak, and more of them should be planted The impression prevails that oak cannot be transplanted, but nursery grown trees properly handled can be moved without serious loss, and in rich soil their growth is quite rapid.

*Burr, Mossy Cup or Over-Cup Oak. (*Q. macrocarpa.*)—Our finest ornamental oak and a magnificent tree even in the most severe locations. In habit of growth, size, form of acorns and cupules it is very variable. This tree and the white oak class, to which it belongs, have very long tap roots. On this account they withstand the treading of cattle or the working of the soil around them far better than the red oak class, which have mostly surface roots, when they grow in forests, but if the red oaks are planted in the

open ground they develop tap roots and stand well. Easily grown from its acorns.

*White Oak. (*Q. alba.*)—A valuable timber tree of slow growth; not particularly useful for ornamental purposes, but its persistent leaves give variety to winter scenery. Grown from its acorns, which should be sown as soon as possible after they fall from the tree.

*Red Oak. (*Q. rubra.*)—A good ornamental and timber tree, with foliage of a deep red color in autumn. Grown from its acorns.

*Scarlet Oak. (*Q. coccinea.*) Has brilliant scarlet foliage after the first frosts of autumn. A beautiful ornamental tree. In growing this care should be taken to select acorns from the trees having the best foliage and habit.

ROBINIA. Locust Tree.

Yellow or Black Locust. (*R. pseud-acacia.*)—Too tender and uncertain over most of this state, and too liable to attacks of borers to warrant its general planting anywhere. But in sheltered positions in the southern part of the state and north to Minneapolis there are occasional groups of trees of good size. It is admired for its racemes of pretty white flowers and graceful foliage. Grown from seed which ripens in autumn, and from sprouts. Flowers in June.

SALISBURIA.

Maiden-Hair Tree or Gingko. (*S. adiantifolia.*)—A very pretty slow growing tree with peculiar fan shaped foliage. A few specimens have grown well near Minneapolis for six years without protection. I have found the young seedlings quite tender. Grown from seed.

SALIX. Willow.

White, Gray or Huntington Willow. (*S. alba.*)—This most valuable willow is too well known as a very desirable tree for shelter belts, or as a street tree, to need much space here, but its great value forbids passing it by without some notice. It is the best pioneer tree for exposed places, and succeeds well everywhere if it has a fair chance. In some

places, notably in Cottonwood county, the larva of the sawflies severely injures it, and it has seldom been planted there of late years. By a little attention at the proper time these insects may easily be destroyed. It can often be used to advantage in ornamental planting, for street trees, along water courses and for a quick growing screen to protect more tender trees. Grown from cuttings.

Wisconsin Weeping Willow. (*S. var.*)—A fine, quick growing, large tree with pendulous branches. I think it valuable over most of the state. The small twigs are sometimes injured at the experiment station, but it quickly outgrows any winter injury it may receive. One of the most desirable weeping trees. Easily grown from cuttings.

Kilmarnock Willow (*S. caprea, var. pendula.*) Too tender for this state, but often sold here by unscrupulous or ignorant agents. It seldom survives one winter.

RUSSIAN WILLOWS—Frequent inquiries are made for the "Russian Willow," with the impression evidently that there is but one tree under this name, when the fact is that at the experiment station we have *seven* kinds received from Russia, and one is as justly entitled to the term "Russian" as the other. These kinds differ widely in value. The most valuable are the following:

Laurel Leaved Willow. (*S. laurifolia.*)—One of the finest and most satisfactory medium sized trees we have, with large dark green leaves that shine as if varnished. Of close, pretty habit it scarce resembles any of the common willows in appearance. A rapid grower. Very desirable for screens and for street and park planting. Easily grown from cuttings.

Russian Golden Willow. (*S. vitellina, var. aurea.*)—Perfectly hardy and a very rapid grower, making a large tree. At all times a good tree, but especially handsome and conspicuous in the latter part of winter and towards sprlng, when the bark turns a light golden yellow, A far better and prettier tree than the common golden willow; very desirable

for screens and wind-brakes. Easily grown from cuttings.

S. acutifolia.—One of the best of the Russian willows. Quite distinct in foliage and habit from other willows; very pretty and graceful. Its leaves are glossy, branches slender and covered with a blue bloom when more than one year old. Not so rapid a grower as the white or golden willow, but it makes a good sized open tree. The foliage resists the work of the saw-fly larva better than that of any willow I know. Perfectly hardy. Easily grown from cuttings.

NAPOLEON'S WILLOW. (*S. Napoleonis.*)—This is a pretty little spreading dwarf willow from Russia, with fine twigs and narrow bluish leaves. It is desirable for covering unsightly banks and for edging water courses. We have grafted this on to the S. acutifolio, and in this form it makes a pretty weeping tree. Very hardy, but the young growth is sometimes a little injured in severe winters at the experiment station. Grown from cuttings.

ROYAL WILLOW. (*S. regalis.*)—A quick growing tree of medium size; close, pretty habit and light, downy, gray colored foliage; very valuable for enlivening plantings and securing contrasts. Much used in fine park planting. We have grown it at the experiment station three years and it seems perfectly hardy. Easily grown from cuttings.

TILIA. Basswood.

*BASSWOOD OR AMERICAN LINDEN. (*T. Americana.*)—A native tree well known as one of the most beautiful native and large ornamental trees we have. It thrives best in the moist, rich land of river bottoms, but does well in any good soil. It is a good street tree in suitable locations, and is not used nearly as much for this purpose as it should be. If young trees are taken from the woods and at once planted out so that the trunk is exposed they are very liable to sun scald. On this account trees planted alone should have their trunks protected with straw or other material until the trees are large enough to shade themselves. Grown from seed which ripens in autumn and from cuttings.

EUROPEAN LINDEN. (*T. Europea.*)— We have tried several of the varieties of this species and found them all too tender to be valuable here.

ULMUS. Elm.

*American or White Elm. (*U. Americana.*)—This is by far the finest tree we have for street planting. While it is found at its best in river bottoms or other moist locations, it also endures remarkably well the intense heat and cold of the prairies of Minnesota and the Dakotas, and should more often be used in timber plantings. Clean in habit, a rapid grower, long lived and beautiful in every way. It varies much in habit. Grown from seed which ripens in June.

English Elm. (*U. campestris.*)—This grand tree has been grown to only a limited extent in this state, but at the central and the Owatonna experiment stations and in Lakewood cemetery, Minneapolis, it is very promising. In habit it differs much from our American elms, the limbs projecting from the trunk at nearly right angles. Grown from layers or suckers.

*Red, Slippery or Moose Elm. (*U. fulva.*)—This is a good small or medium sized tree; desirable for forest planting. The red wood is straight grained and a valuable timber for many purposes. Not so desirable for street planting as the white elm. Grown from seed which ripens in June.

Weeping Slippery Elm. (*U. fulva var.*)—This is of very strong growth, and pendulous habit. When growing rapidly, some branches are apt to run up too erect for symmetry; these will assume their proper positions if some small weight is tied to their ends. A useful variety for occasional use in ornamental planting. Grown by grafting it on white or slippery elm.

*Cork or Rock Elm. (*U. racemosa.*)—A valuable native tree of large size that varies very much. One form of this has leaves that remain on it all winter. This has much harder and stronger wood than the red elm. A valuable tree for ornamental or timber planting. Grown from seed which ripens in early autumn.

Camperdown Weeping Elm. (*U. var. montana, Camperdown.*)—A very beautiful weeping tree, not generally regarded as hardy here, but, at the experiment station, it has come through the past three winters in vigorous condition. In Lakewood cemetery, Minneapolis, it is holding on well.

EVERGREEN TREES.*

ABIES. Balsam.

*BALSAM FIR, BALSAM SPRUCE OR BALM-OF-GILEAD FIR. (*A. balsamea.*)—This well known evergreen is very abundant in eastern Minnesota. It makes a slender tree of much beauty in moist locations and rich soil, but it is not nearly so valuable for screens or ornamental planting generally as the white or Norway spruce, and should be used very sparingly in dry locations. It often loses much of its beauty when old, especially if at all affected by lack of water in the soil. Grown from seed.

A. concolor.—This is a Rocky Mountain fir with long, light colored, beautiful foliage. It varies much in color, some specimens being a soft light pea-green color. Well grown specimens are very beautiful. When young it rather inclines to spread out and to be sprawling in habit, but in a few years it takes a start upwards and makes a good tree. We have grown it at the experiment station seven years and it has shown itself to be very hardy, but its slow growth will prevent its becoming very popular. Grown from seed.

NORDMANN'S SILVER FIR. (*A. Nordmanniana.*)—Not satisfactory at the experiment station as the foliage sun burns badly.

PINUS. Pines.

*WHITE OR WEYMOUTH PINE. (*P. strobus.*)—One of the most valuable and beautiful native evergreen trees we have. Long lived, hardy and of rapid growth in almost any soil or situation when once established, in eastern, north-eastern and

*All the evergreen trees referred to in this bulletin are generally grown from seed sown early in the spring. Occasionally, to perpetuate some peculiarity, some varieties are grown from cuttings by grafting, but those so propagated are not as long lived or hardy as plants from seed.

southern Minnesota, but reports from extreme western Minesota would indicate that it is somewhat unreliable there, and that the Scotch pine is a better tree to plant there. Grown from seed that ripens in autumn.

*Red or Norway Pine. (*P. resinosa.*)—For ornamental planting this native tree rivals the white pine. It is of good form, rapid growth, long lived and perfectly hardy when once established. Young trees of this pine have for several years been difficult to obtain, and but few nurserymen offer them, and when they do it is at about twice the price of white pine. The seed, too, we have found almost impossible to obtain for the last two years. Grown from seed.

Scotch Pine. (*P. sylvestris.*)—Introduced from Europe; a quick growing tree and a favorite with the planters; very hardy and easily grown, but in this climate it seems to mature in about twenty years and then begins to look scrawny and bare; a valuable tree to plant as a pioneer evergreen. A form of this, called Riga pine has been introduced into this country from Russia and is represented as a much larger tree and much longer lived than the ordinary Scotch pine in this climate. We have several specimens now ten years old on the grounds of the experiment station; they grow well and may be somewhat closer in habit than the Scotch pine; they are holding their own, but we think not more so than the common Scotch pine, though we have not had them long enough to draw definite conclusions as to their value. Grown from seed.

Austrian or European Pine. (*P. Austriaca.*)—Introduced from Europe; somewhat resembling the Scotch pine, but with longer needles and a more symmetrical, candelabra like habit; it is open to the same objection as the Scotch pine and is not nearly so hardy or as rapid a grower; very handsome and useful for giving variety to plantings. Grown from seed.

Heavy Wooded or Bull Pine. (*P. ponderosa.*)—This is a Rocky Mountain species that seems to promise much usefulness in this state; it is the only pine found growing in the extremely dry climate of northwestern Nebraska and among

the foot hills, where it is often found growing alone in exposed places It does not thrive in the humid air of the eastern states. From what we know of this tree it would seem to be well adapted to the western prairies of this state; well worth trying and one of the easiest to grow from seeds.

Dwarf Mugho Pine. (*P. Mughus.*)—Introduced from Europe. A very hardy and long lived dwarf pine, seldom growing over six feet high; shrub like in habit; very thick and bushy. It is very desirable for ornamental planting and single specimens are often very handsome; it also makes a good wind break; of rather slow growth; the plants vary much in aspect but all have the same dwarf habit. Hon. L R. Moyer, of Montevideo, Chippewa County, Minn., thinks this the hardiest and longest lived of cultivated pines. Grown from seed.

PICEA. Spruce.

*White or Blue Spruce. (*P. alba.*)—This is perhaps the most valuable spruce we have. When once established it is very hardy and beautiful; much hardier than the Norway spruce, but in habit not so graceful and more resembling the balsam fir. The seed of this tree is difficult to obtain, and the young trees generally cost considerably more than the Norway spruce. The black spruce is frequently substituted for the white spruce, which it somewhat resembles, when young. A native timber tree with cones about two inches long that fall off when ripe. Grown from seed.

Norway Spruce. (*P. excelsa.*—)A fine tree that is generally doing well in the state. A strong, very fine grower, and it assumes a beautiful pyramidal form, and drooping habit when fifteen to twenty feet high. Its foliage is occasionally browned a little but it holds on well. Very desirable for wind breaks. On account of the scarcity of the white spruce this tree has been and is destined to be largely planted. Its cones generally form near the tops of large trees and are often eight, and seldom less than six inches long. Easily grown from seed.

Black or Double Spruce (*P. nigra.*) is far more abundant in our native woods than the white spruce, which

is quite rare. It is comparatively worthless for planting in this state, seldom giving satisfaction. A slow grower, with a decidedly dirty aspect when it commences to bear seed, as the cones do not drop off, like those of the Norway and white spruces, but remain on the trees decaying for years; this, with its enfeebled growth which shows when the trees first bear seed, make it quite unsightly. The planting of this spruce has led to much disappointment. Unscrupulous persons often sell this for the white spruce, which it somewhat resembles when young. Cones small, one to one-and-a-half inches long. Trees often bear cones when not over five feet high, but I have never seen the white spruce have cones until much larger and older.

Colorado Blue Spruce. (*P. pungens.*)—This is a tree of exceeding great beauty from the Rocky mountains, where it is found growing in very severe exposures. It seems to be of wide adaptablility, succeeding equally well in North Carolina and in Nebraska. Its chief beauty lies in the beautiful light blue color of some specimens. In growing it from seed, it is found that only about one-third of the seedlings have the desired blue color, while the remaining two-thirds are of a rich green color. As yet there are no large specimens in this state. It has been grown for seven years in the nursery at the experiment station and it appears as hardy as the white spruce, while it is of a far prettier habit. Judging of it from observations made here and in eastern states, where there are quite large trees, I am led to believe that it will become very popular and prove a decided acquisition to our list of ornamental evergreen trees. Not so rapid a grower as the white spruce. Grown from seed,

Engleman's Spruce. (*P. Englemanii.*)—Introduced from the Rocky mountains. This somewhat resembles the Colorado blue spruce, but with blunt pointed needles. Very pretty and desirable. Not thoroughly tested. Grown from seed.

PSEUDOTSUGA.

Douglas Spruce. (*P. taxifolia.*)—Another Rocky mountain conifer which is quite unique in its botanical relation to

other conifers. In foliage it somewhat resembles the hemlock, as its name implies. Good authority reports this tree as tender here when raised from seed grown on the western slopes of the Rockies, while seed from the eastern slopes produces plants that are very hardy, but not so hardy as the white spruce. In its native habitat it produces a great amount of large timber resembling and valued for the same purposes as hemlock. We have grown it seven years at the experiment station and find it of rapid growth, and somewhat irregular but erect habit. Easily transplanted and very hardy. It varies much in color, some specimens rivaling the Colorado blue spruce in color and beauty of foliage. Grown from seed. The young seedlings, however, are extremely tender and liable to sun scald and to "damp off."

RETINISPORA. Japan Cedar.

JAPAN CEDAR. (*R. plumosa.*)—This beautiful evergreen is too tender to be grown successfully in Minnesota. The rest of the species and varieties are probably as tender and not even of promising hardiness. As specimen plants to be grown in tubs and wintered in the cellar they are very desirable. Grown from cuttings or layers.

TSUGA CANADENSIS. Hemlock.

*HEMLOCK OR HEMLOCK SPRUCE. (*T. Canadensis.*)—This native tree is found abundantly in parts of Wisconsin, but only sparingly in Minnesota. It is a valuable timber tree of magnificent habit and proportions. There is a very general feeling among the planters that it is not hardy here, but at the experiment station we find that when planted among other trees it is very hardy, only occasionally having its foliage browned. Well worthy of more extended use in somewhat sheltered locations. Grown from seed.

JUNIPERUS. Juniper.

RED CEDAR OR JUNIPER. (*J. Virginiana.*)—Well known, and found growing in many parts of Minnesota. It does well in the driest and most exposed, as well as in the most sheltered locations, and forms an admirable wind break. When grown in alternate rows with white or Scotch pine a

screen is formed as impenetrable as a stone wall. Grown from seed that should have the outer coat taken off with potash lye, and which often then will remain dormant for a year in the soil before growing. The native form of this is much hardier than that found further south.

Trailing or Savin Juniper. (*J. Sabina var. tamarisifolia.*)—A pretty, dwarf, trailing native juniper which is readily pruned to a variety of forms. It makes a fine plant and is very desirable for occasional use. Grown from cuttings and layers.

THUJA. Arbor Vitæ.

*Arbor Vitæ or White Cedar. (*T. occidentalis.*)—Very common in swamps in eastern Minnesota and Wisconsin. Valuable for screens and hedges. It will not stand well in very dry locations, but makes a good growth in any retentive soil when once established. Grown from seed. It varies much under cultivation and most of its varieties are desirable. Among the best of these are the following:

Siberian Arbor Vitæ. (*T. occidentalis, var. Siberica.*)—One of the best varieties for favorable locations, but is not as hardy as the following species or the next. Of a dark rich green color and compact habit. Grown from cuttings or layers.

Pyramidal Arbor Vitæ. (*T. occidentalis, var. pyramidalis*). Of upright pyramidal form, and very distinct, fine, handsome foliage. It gives variety when planted among other evergreens. Grown from cuttings or layers. Hardy.

Golden Arbor Vitæ. (*T. occidentalis, var. Douglasii.*)—A strong growing kind. In habit like the common arbor vitæ but with bright golden color; conspicuous and pretty, but occasionally it severely sun scalds. Grown from cuttings and layers.

SHRUBS.

ARALIA.

ARALIA OR ANGELICA TREE. (*A. Mandshurica.*)—A very odd looking bush with large compound leaves that give it a semi-tropical aspect. With us it kills to the ground each season, but starts quickly from the roots in the spring, and makes a growth of from three to five feet. It prefers a moist situation.

BERBERIS. Barberry.

COMMON BARBERRY. (*B. vulgaris.*)—A strong growing shrub with handsome foliage, many sharp prickles, yellow flowers in June, and red fruit. Found occasionally spontaneous in this state. It makes a small loose hedge and is desirable for grouping. Very hardy here, but it fruits only sparingly. Its foliage is often disfigured by the cluster cup fungus. Grown from seed that ripens in autumn.

PURPLE LEAVED BARBERRY. (*B. vulgaris, var. purpurea.*)—A fine ornamental shrub with purple foliage and small yellow flowers in May. Valuable for contrasting with plants of lighter foliage. When grown from seed a large proportion of the plants will often be green in color, but most of them will be purple. It may also be grown from cuttings of the half ripened wood.

THUNBERG'S BARBERRY. (*B. Thunbergii.*)—A very pretty spreading bush of small size. The foliage is small and bright green in summer, changing to a bright red in autumn. It is not much affected by the cluster cup fungus. Desirable. Grown from cuttings of the green wood, or from seed which ripens in autumn.

CARAGANA. Pea Tree.

Caragana or Siberian Pea Tree. (*C. arborescens.*)—A Siberian shrub of close,neat habit, locust like leaves and leaflets and bright yellow, pea-shaped flowers early in spring, followed by long, slender pods. Very pretty for a division line between city lots and for grouping. It bears pruning well and is probably one of the hardiest of cultivated plants. Grown from seed that ripens in autumn.

C. frutecsens.—A smaller Siberian shrub than the above, with yellow flowers. Valuable.

CORNUS. Dogwood.

Red Osier Dogwood or Red Twigged Dogwood. (*C. stolonifera.*)—A native shrub from three to six feet high, with bright red bark in winter, and small white flowers in June. It sends up many sprouts from the roots. Very pretty either singly or grouped with other shrubs. Propagated by cuttings, layers and suckers.

C. sanguinea.—A European species, similar to the above in foliage and flowers, but the bark is of a dark red color, and it does not sprout from the roots. Valuable for ornamental planting. Propagated by cuttings and layers.

DIERVILLA. Weigela.

D. rosea.—There are many species and varieties of weigela that are very beautiful, but most of them are quite tender in this state, unless heavily protected in winter. This species, however, is quite satisfactory here, and is well worth growing by those having a somewhat protected location. It produces large rose colored, trumpet shaped flowers in June. Pretty and desirable. Very hardy, but is occasionally injured by severe winters and is improved by slight protection. Grown from green wood huttings and from layers.

EUONYMUS. Burning Bush.

Euonymus, Burning Bush or Spindle Tree. (*E. atropurpureus.*)—This is our native species. It forms a shrub or small tree six to fourteen feet high. Cultivated for its pretty and striking appearance in autumn when covered with

its abundant crimson fruit. Hardy. Propagated by seed that ripens in autumn.

FORSYTHIA. Golden Bell.

F. Fortunei.—This shrub generally comes through our winters without much injury, but, while it grows rapidly it seldom, if ever, flowers at the experiment station. Grown from green wood cuttings and from layers.

F. viridissima.—This behaves much like the above.

HYDRANGEA. Hardy Hydrangea.

H. paniculata.—This is the original type of the popular large flowering hydrangea. It has an open panicle and only a few flowers sterile. A very pretty shrub, but not generally so much admired as the next and not much grown.

Large Flowered Hydrangea. (*H. Paniculata, var. grandiflora.*)—This is probably the most popular hardy shrub in cultivation. It is admired for its handsome large clusters of white flowers in August, when but few shrubs are in blossom, and none so conspicuous. It is easily grown, and is generally hardy without protection. Of clean, robust habit, it should be in every collection. Easily propagated from hard or soft wood cuttings and from layers. Very hardy at the experiment station, but it winter kills completely in very trying situations on the prairies, unless heavily protected.

HYPERICUM. St. John's Wort.

H. aureum.—We have had this shrub two winters in a somewhat protected place, and it has proven very hardy and satisfactory so far. It has large, bright yellow flowers in August and September. Propagated by green wood cuttings and seeds.

H. kalmianum.—With smaller flowers than the above and of a more spreading habit. Flowers in August. Very hardy. Propagated by seed.

H. *salicifolia.*—This we received from Prof. Budd, but have never been able to winter it. Too tender.

LIGUSTRUM. Privet.

P. vulgaris.—As ordinarily grown this is very tender,

but we have a form from Poland that has stood the last three winters without serious injury. Increased from cuttings.

California Privet. (*L. ovalifolium.*)—Not hardy.

LONICERA. Bush Honeysuckle.

L. Tartarica.—There are several varieties of this and all are hardy, desirable, and as satisfactory as any ornamental plant grown. They make large bushes and are never injured by severe weather. The flowers are pink and white. We also have a variety with larger pink flowers than the species called the *grandiflora* that is very desirable. Flowers in June, followed by yellow or red berries. Grown from soft wood cuttings, layers and seed.

PHILADELPHUS. Syringa, or Mock Orange.

Garland Syringa. (*P. coronarius.*)—A well known and popular favorite, much prized for its highly scented white flowers, which are produced in June and in great abundance. It is only occasionally injured in our severe winters and it quickly outgrows any set back it may receive.

P. Columbianium.—A late flowering species with large white flowers that we received from Arnold Arboretum. Very beautiful and of promising hardiness.

P. grandiflorus.—Has slightly fragrant flowers that are very large and showy. Valuable.

Philadelphus, var. 144.—We received this from Russsia through Prof. Budd. It has very large white, slightly fragrant, handsome, flowers, and is of straggling habit. Probably form of *P. grandiflorus.* Hardy and valuable. Grown by cuttings.

Gordon's Syringa. (*P. Gordonianum.*)—A fine late flowering variety with large flowers. Very hardy.

PHYSOCARPUS. Spiræa.

*Spiræ or Nine-Bark. (*P.opulifolius.*)—A strong growing shrub from six to ten feet high, with clusters of white flowers late in June. Desirable for screens and groups. Grown from seed or cuttings.

Golden Spiræa or Nine-Bark. (*P. opulifolius, var.*

aurea.)—A most graceful shrub that pleases everyone by the contrast of its graceful form and golden green leaves with the foliage of other plants. It is especially desirable as a single specimen for the lawn where something nice is wanted. White flowers in clusters in June. Very satisfactory. Grown from cuttings and layers.

POTENTILLA. Cinquefoil.

*Potentilla or Shrubby Cinquefoil. (*P. fruticosa.*)—A hardy uative shrub about three feet high, with pretty golden yellow flowers all summer. Very desirable and satisfactory even in the most exposed, or in very dry situations. Grown from seed and layers.

RHAMNUS. Buckthorn.

English Buckthorn. (*R.catharticus.*)—The well known and popular hedge plant of the eastern states and Europe. Of robust growth and pretty habit, with white flowers in June, followed by black berries. It bears close pruning without injury. It may be grown as a small tree or shrub. Perfectly hardy in this state even in very severe locations. "Exceedingly desirable. Plant without fear." Propagated by seed that ripens in autumn.

RHUS. Sumach.

Smoke Bush or Purple Fringe. (*R. cotinus.*)—Admired for its airy clusters of curious, fringe-like flowers that to the popular mind resemble brown smoke. It can only be grown successfully in this state in favorable locations, and is liable to serious winter injury elsewhere. Grown by seed and layers.

*Smooth Leaved Sumach. (*R. glabra.*)—A native kind that may often be used to advantage for groups in ornamental planting. Attractive in summer with its long, graceful compound leaves and clusters of dark colored fruit, but in autumn the plant is gorgeous in its crimson coloring. Propagated by seed and root cuttings.

Cut Leaved Sumach. (*R. glabra, var. laciniata.*)—This is a form of the last, but with finely divided foliage that gives it something of the aspect of a large fern. Very pretty. Hardy when well established. Propagated by root cuttings.

RIBES. Flowering Currant.

R. alpinum.—A dwarf kind with spreading habit and small, yellow flowers.

Yellow Flowering or Missouri Currant. (*R. aureum.*)—A well known, popular shrub having a great profusion of long yellow flowers early in the spring, followed by a few purple, black shining berries. Of the easiest culture, hardy and desirable. Propagated by cuttings, divisions and layers.

Gordon's Currant. (*R. Gordonianum.*)—Has not wintered well at the experiment station, and we think it too tender without protection.

ROSA RUGOSA. Japanese Rose.

We reserve a report on hardy and desirable roses for a subsequent bulletin, but at this time think it best to call attention to this very desirable species, which has seemingly been overlooked by planters. It has been said that we have never received a native plant from Japan that was hardy in this state, and at first thought this plant might seem an exception to the rule, yet the truth probably is that it is a native of Siberia, from whence it was introduced into Japan.

R. rugosa.—We have this in two colors, pink and clear, pure white. The plants grow about three feet high and are exceedingly vigorous and thrifty. The bark is covered with slender prickles. The leaves are large, thick and of a dark, glossy green color, which they maintain early and late, in dry or in wet weather. When other roses have lost their foliage or look brown from the attacks of the rose slug or thrip, the leaves of the rugosa are as bright as ever. I have seldom seen a leaf of it injured by insect or fungi. The flowers are single, of good form and from three to four inches across; buds long, pointed and very beautiful. They flower all summer and often into September, and have very large, bright colored fruit. We have grown it unprotected in a very exposed place for three years, yet it has never been injured. I think it hardy in any good soil, if slightly protected, and perhaps without any protection. Grown from cuttings

of the underground stems, by budding and from layers. Plants grow readily from seed and seedlings, and are of various shades of red and white.

Semi-Double Rosa Rugosa. (*rosa rugosa, var. flora plena.*)—A semi-double form of the above is offered by nurserymen which is quite pretty, but it lacks the character and elegance of the species.

SAMBUCUS. Elder.

*Common Elder. (*S. Canadensis.*)—A native shrub of robust habit with white flowers in large flat clusters in July, followed by black berries that are often used for a medicinal wine. Hardy and desirable; grown by divisions, seed and cuttings.

*Red Berried Elder. (*S. racemosa.*)—A native shrub of robust habit with white flowers in pointed clusters in May, followed by bright red berries. Very pretty and conspicuous in both flower and fruit; propagated by cuttings, divisions and seed.

Cut Leafed Elder. (*S. racemosa var. laciniata.*)-A strong growing variety from Europe with dark green, deeply cut foliage; a good ornamental shrub; propagated by cuttings and divisions.

Golden Elder. (*S. nigra, var. aurea.*)—An elegant form of the European elder with bright, golden-yellow foliage and white flowers in flat clusters. It is very valuable for enlivening shrubberies and forms a most beautiful contrast with plants of more somber hue. It is sometimes killed back a little but has never been seriously injured. To get the best effect from it the young shoots should be occasionally pinched back in early summer. Very hardy and desirable. Easily grown from cuttings.

SPIREA. Meadow-Sweet.

S. Van Houttii.—A strong-growing, hardy shrub of handsome habit that is covered in June with masses of large white flower clusters. This is by far the best of the species for this state. Hardy; propagated by cuttings and divisions.

S. obovata.—A strong growing, perfectly hardy shrub, covered with clusters of white flowers in May. Grown from cuttings and divisions. Pretty and desirable.

Douglas' Spirea. (*S. Douglasi.*)—A low shrub of which there are several varieties with pink or white flowers in July and August. Very hardy. Propagated by divisions and cuttings.

S. lanceolata or *S. Reevesii.*—A handsome shrubby spirea with showy white flowers in May. Of good habit and desirable. Propagated by divisions and cuttings.

Hypericum Leafed. (*S. hypericifolia*)—A dwarf species with white flowers early in the season.

Fortune's Spirea. (*S. Fortunei.*)—A low growing spirea of which there are varieties with red and white flowers. Very pretty and useful.

Bridal Wreath or Plum-leafed Spirea. (*S. prunifolia. var. flore pleno.*)—A very beautiful shrub with closely set double white flowers. It is sometimes injured in winter in very severe locations. Desirable.

Thunberg's Spirea. (*S. Thunbergii.*)—This is a pretty, graceful spirea with narrow, pointed leaves and white flowers, which are produced early in the spring, before the leaves. At the experiment station we have found it too tender to be desirable unless covered in winter.

*Nine bark Spirea. (*S. opulifolia.*)—For this see *Physocarpus.*

Golden Spirea. (*S. opulifolia, var. aurea.*)—For this see *Physocarpus.*

Ash Leafed Spirea. (*S. sorbifolia.*)—A vigorous species with compound leaves resembling those of the mountain ash, and long, elegant panicles of white flowers in July. It suckers some from the root and is easily increased from root cuttings.

SHEPHERDIA. Buffalo Berry.

*Buffalo Berry. (*S. argentea.*)—A very excellent shrub or small tree (4-10 feet high) found abundantly along water courses in the Dakotas and Montana. Its imperfect flowers are produced early in the spring, before the leaves, and are

inconspicuous. Its leaves and new growth are silvery white and give the plant a very conspicuous, soft-silvery aspect. In growing it from suckers pulled from wild plants, I have found it difficult to secure pistillate plants, and consequently the fruit. The fruit is red, with one quite large seed, and is very pretty. It is quite acid and makes a good jelly or sauce, but I doubt much if it ever becomes popular for its fruit where currants can be easily grown, on account of its large seeds. The foliage of the plants vary in color. The prettiest we have came from Wyoming. Perfectly hardy, and a most desirable ornamental shrub.

SYMPHORICARPUS. Snow or Wolf Berry.

Snowberry. (*S. racemosus.*)—A hardy native shrub that has inconspicuous flowers, followed by white berries that remain on the branches the greater part of the winter. It has long been cultivated; grows about four feet high, and is very desirable for ornamental planting.

SYRINGA. Lilac.

Common Lilac. (*S. vulgaris.*)—Few shrubs are so well known and popular as this. It is perfectly hardy, grows freely, and flowers abundantly in any soil or situation, but it will repay any extra care taken in manuring it and keeping the suckers pulled off. There are a great many very beautiful varieties which have red, blue or white flowers in May or June. Leaves heart shaped. The species and some of its varieties are grown from seed, cuttings or suckers, while other varieties are only grown by grafting.

Persian Lilac. (*S. Persica.*)—Not so strong a grower as the common lilac, but hardy and desirable. Flowers resembling those of the common lilac, but in more open clusters and bluish purple or white in color. Leaves narrower than in the common lilac and more pointed. Hardy. Grown from cuttings.

Josika's or Chionanthus-Leaved Lilac. (*S. Josikæa.*)—We have grown this species at the experiment station four years, and it appears as hardy as the common lilac. Its foliage is very large and of a dark, glossy green color. Its flowers are produced just after the common lilacs are

done flowering. A robust grower. Grown from cuttings and layers. Very desirable.

TAMARIX. Tamarisk.

T. amurensis.—A pretty, graceful shrub with fine, light, cedar-like foliage. We have grown it for six years in our nursery. It kills nearly to the ground each winter, but is well worth growing in a small way.

VIBURNUM. Arrow Root.

*High Bush Cranberry. (*V. opulus.*)—A well known native shrub, found in moist land. From four to to ten feet high. Flowers in white flat clusters in June, followed by clusters of red or yellow fruit, which hang on into the winter. Hardy, vigorous and desirable. The red, acid fruit is valued as a substitute for cranberries, and can often be profitably cultivated. Increased by seed, layers or cuttings.

Snow Ball or Guelder Rose. (*V. opulus, var. sterilis.*)—A well known form of the high bush cranberry with sterile white flowers in rounded clusters in June. A very popular shrub. Grown from layers and cuttings.

*Arrow Wood.(*V. dentatum.*)—A large native shrub of clean habit, with white flowers in June. Desirable for large groups.

*Sheep Berry. (*V. lentago.*)—A native shrub of robust, pretty habit and handsome flowers in the spring. Perfectly hardy and very desirable.

ZANTHOXYLUM. Toothache Tree or Prickly Ash.

**Z. Americana.*—A native shrub or small tree. Perfectly hardy. Valuable for variety in lawn planting. It also makes a very excellent, impenetrable hedge. Grown from seed which ripens in autumn.

VINES AND CLIMBING SHRUBS.

ACTINIDIA.

A. arguta, wrongly called *A. polygama*.—A rampant growing ornamental vine from Japan. This has been grown in a small way by R. J. Mendenhall, of Minneapolis, and has been found to be unreliable. At the experiment station we lost ours the first winter it was planted.

AKEBIA.

A. quinata.—A Japanese vine of pretty habit, but too tender at the experiment station.

AMPELOPSIS.

*Virginia Creeper or American Ivy. (*A. quinquefolia.*)—Our best climber and a native of our woods; of strong growth, with beautiful, bright crimson colored foliage in autumn. Unsurpassed for covering porches and unsightly fences, etc. One of the most beautiful division lines between property that I have ever seen was a fence covered with this climber. It needs liberal manuring to enable it to do its best. A variety of the above, known as Englemann's, has shorter joints and clings rather better to walls. Perfectly hardy and well known. Grown from layers, cuttings and seeds.

Japan or Boston Ivy. (*A. Veitchii.*)—Where hardy this is the best of creepers for stone walls, and is the vine used so much on public buildings, etc., in the eastern and central states. Unfortunately we have found it to be too tender for use in Minnesota. In very favorable locations it can be grown if well protected in winter. It is very much more tender the first two years after setting out than it is after having become well established. Grown from layers, cuttings and seeds.

ARISTOLOCHIA. Dutchman's Pipe or Birthwort.

**A. Sipho.*—A native vine with large leaves and curious flowers. It can be grown in protected locations, but is not generally desirable. Grown from seed.

CELASTRUS.

*Bitter-Sweet or Climbing Celastrus. (*C. scandens.*)—A strong growing, native twining vine of clean habit. It is very conspicuous and pretty when covered with its orange colored seed pods. Hardy. Very desirable. Grown from seed and layers.

CLEMATIS.

European Sweet Clematis. (*C. flammula.*)—With small, fragrant white flowers. Not hardy at the experiment station.

C. Jackmanni.—A most beautiful clematis, with large, purple flowers. Desirable in very favorable locations, but not generally satisfactory here unless carefully protected. Grown from cuttings, layers or by root grafting.

C. coccinea.—A slender growing vine with red flowers. A native of Texas. Quite hardy, but not generally satisfactory. Should be protected in winter. Grown from seed or layers.

*Virgin's Bower. (*C. Virginiana.*)—This is our beautiful native clematis. It is covered with a profusion of small, white, fragrant flowers in August. A strong, healthy grower and a most desirable vine for covering porches, etc. Very nice for contrasting with the Virginia Creeper. Grown from seed or layers.

C. Viticella.—A very pretty climber with large blue or purple flowers, which are produced all summer. A very satisfactory vine. Grown from seed, layers or cuttings.

LONICERA. Honeysuckle.

**L. Sullivantii.*—A native honeysuckle which does well under cultivation. Hardy.

L. Sempervirens.—Hardy if protected.

Japan Golden-Leafed Honeysuckle. (*L. brachypoda.*)—Too tender.

HALL'S JAPAN HONEYSUCKLE. (*L. Halleana.*)—A beautiful vine, producing an abundance of flowers all summer. The flowers are at first white and then change to yellow. Hardy only when carefully protected in winter. Grown from layers and cuttings.

MENISPERMUM. Moonseed.

M. Canadense.—A pretty, slender native vine that can sometimse be used for variety. It succeeds well in partial shade. Grown from seed.

WISTARIA.

This may be grown in sheltered locations if protected, but is not generally satisfactory here, as it kills nearly to the ground every winter.

VITIS.

WILD GRAPE. (*V. riparia.*)—The unfruitful or staminate form of this is a very desirable vine for exposed places. It is somewhat coarse in habit, but for coarse work is just the thing and is very beautiful when covering a dead tree or any unsightly object. The fruitful form is of slow growth, but this kind make a very robust vine and is very fragrant when inflower. Hardy anywhere. Grown from cuttings or layers.

HERBACEOUS PLANTS.

ACHILLEA. Yarrow or Milfoil.

ROSE FLOWERED YARROW. (*A. millefolium, var. rosea.*) Like the common white yarrow in form of growth and flower cluster, but different in the color of its flowers. Desirable.

DOUBLE-FLOWERING YARROW. (*A. Ptarmica, var. flore plena.*)—This has pretty, white flowers that are much longer than those of the common yarrow. Very desirable.

AQUILEGIA. Columbine.

A. vulgaris.—A well known pretty plant with flowers of many colors, varying from white to dark blue. Desirable.

ALTHEA. HollyhockS.

A. rosea, var.—Well known and valuable. They should be protected by a heavy mulching each winter.

ARUNDO. The Reed.

A. Donax.—A handsome reed growing from 8 to 10 feet high. It requires very heavy protection to carry it through the winter here, and we have found it safest to winter the roots in a cold cellar. Desirable.

A. Donax, versicolor.—This is a beautiful form of the above with yellow leaves striped with green. Very desirable. More tender than the above, and should be wintered in a cold cellar.

ASCLEPIAS. Milkweed.

**A. incarnata.*—A native milkweed with fine, flesh colored flowers. Well worthy of cultivation.

**A. tuberosa.*—A beautiful native milkweed with gorgeous, bright orange flowers. Very desirable.

ASTER.

There are several species of our native aster that are

very showy, pretty and useful for ornamental planting, and as they are all hardy and do not need special care, they should be more generally cultivated.

BOCCONIA.

B. cordata.—A strong growing plant of striking and very beautiful habit. For best results it should be protected in winter. Desirable.

CONVALLARIA. Lily of the Valley.

C. majalis.—The well known little favorite. Flowers in early spring. Increased by divisions.

COREOPSIS. Tickseed.

**C. lanceolata.*—A beautiful and satisfactory perennial with showy, golden yellow flowers. Flowers nearly all summer. Desirable. Grown from seed.

DELPHINIUM. Larkspur.

The perennial larkspurs are very hardy and few plants produce as beautiful and striking an appearance when in blossom. Very desirable. In flower nearly all summer. Grown from seed or cuttings or divisions.

DICENTRA or DIELYTRA. Bleeding Heart.

D. spectabilis.—A handsome and valuable herbaceous plant. Very common in gardens. Flowers in May. Increased by division of the root.

DICTAMNUS. Gas Plant.

D. Fraxinella.—Not hardy at the experiment station unless heavily protected. Very pretty and desirable. White or pink flowers in June.

ERIANTHUS. Pampas Grass.

E. Ravennæ.—Not hardy at the experiment station unless heavily protected.

EULALIA. Pampas Grass.

E. Japonica, var. zebrina; E. Japonica, var. variegata, and *E. Japonica, var. gracilima.*—These are very beautiful when well grown, but at the experiment station we have lost them when not heavily protected in winter.

FUNKIA. Plaintain Lily.

F. cærulea.—Hardy when protected.

GYPSOPHILA. Chalk Plant.

Baby's Breath. *G. paniculata.*—An herbaceous plant with beautiful, fine, small white flowers in large loose panicles. Valuable for bouquets. Increased easily from seed or by divisions. Flowers in July and August.

HELIANTHUS. Sunflower.

Double Perennial Sunflower. (*H. multiflorus, fl. pl.*)—A very beautiful plant when well grown. It requires much protection and I think it best to bring the roots into the cellar in autumn. Flowers about the size of a large dahlia, which they resemble. Grown from divisions.

Our native species of Helianthus are very excellent and satisfactory in every way as border plants and are not as much appreciated as they should be.

H. Maxmillianus.—Is perhaps the finest native species we have.

**H. tuberosa.*—A good native species.

IRIS. Fleur de Lis.

German or Common Iris. (*I. Germanica.*)—A very beautiful perennial with peculiar, large bright colored flowers in May. There are several varieties.

I. Kæmpferi.—We have not yet grown this Japanese species at the experiment station but judging from the behavior of a few specimens elsewhere I think it at least of very promising hardiness in moist land.

KNIPHOFIA. Tritoma or Red Hot Poker Plant.

Torch Lily or Flame Plant.—Not hardy at the experiment station, but a very satisfactory plant if the roots are wintered in a cold cellar. Flowers in latter part of summer or in autumn. Grown from divisions.

PÆONIA. Pæony.

Tree Pæony. (*P. Moutan.*)—These are rather tender but may be successfully grown in favorable locations if protected by a heavy mulch in winter.

HERBACEOUS PÆONIES.—These very valuable plants are much neglected and yet they are among our best hardy plants. Once planted they need no further care, and each succeeding year only adds to their beauty. The varieties commonly known are desirable, but the newer varieties produce very large, handsome, regularly formed blooms, resembling large roses. For several years these blooms have been much sought after for elegant fashionable boquets. There are many varieties distinguished by the form, size and color of their flowers, and the time of flowering. Flowers in June and July.

PHLOX.

P. decussata, var.—A most valuable class of herbaceous plants. Those who know only the old kinds will be surpris ed at the beauty of many of the newly introduced varieties. For the best results these should be protected in winter and transplanted every two years. Flowers in August.

POLYGONUM.

MOUNTAIN FLEECE. (*P. cuspidatum.*)—A strong growing, erect plant of pretty habit, producing a profusion of small white flowers the last of August. Perfectly hardy. Increased by cuttings and divisions.

PYRETHRUM.

P. roseum.—A hardy perennial of easy culture, producing a great abundance of large, daisy like flowers in many colors in June. The flowers of this and one or two other species are grown to make the famous insect powder. Very desirable.

SPIREA. Meadow Sweet.

S. Japonica, (*Astilbe Japonica.*)—A very beautiful herbaceous species with delicate white flowers in June. Very hardy and desirable. Does well in partial shade, and when somewhat protected in winter.

S. Ulmaria.—Very beautiful when well grown, but the foliage burns badly in the full sunshine, and it should only be planted in partial shade.

TANACETUM. Common Tansy.

T. balsamita.—A well known, strong growing perennial

with small yellow flowers, and pleasantly scented foliage. Of reputed medicinal value.

TRADESCANTIA. Spiderwort.

T. Virginica.—A pretty, showy native plant about eighteen inches high, with blue or white flowers. Desirable.

VIOLA. Pansy or Heart's-Ease.

V. tricolor.—These should be grown from seed each year. For early spring flowering the seed should be sown in early August, and the plants will winter in good condition if slightly protected. For summer flowers sow the seed early in spring.

YUCCA Adam's Needle.

Y. filamentosa.—An herbaceous plant with green, thread like, pointed leaves having a very tough fibre. Its beautylies in its conspicuous, creamy-white flower cluster, which is about four feet from the ground. It requires winter protection and even then is not satisfactory in flowering.

TABLE OF HARDINESS.

DECIDUOUS TREES.

Page	Common Name	Botanical Name	Experiment Station Notes	Wyman Elliott, Minneapolis	L. R. Moyer, Montevideo, Chippewa Co.	Prof. C. B. Waldron, Fargo	J. S. Harris, La Crescent, Minn.	E. H. S. Dart, Owatonna, Minn.
175	*White or Soft Maple	Acer dasycarpum	Hardy	Hardy	Hardy	Hardy	Hardy	I like it
175	Cut Leaved Maple	" " var. Wierii	Very hardy	Hardy				Doubtful
175	*Sugar Maple	" saccharinum	Hardy.	Hardy.	Not hardy		It often does very well	Unreliable
176	*Norway Maple	" platanoides	Not hardy	Not hardy			Not hardy	
176	Schwedler Maple	" " var. Schwedlerii	Valuable (?)					
176	Rittenbach Maple.	Acer platanoides var. Rittenbachii	Valuable (?)					
176	*Red Maple	Acer rubrum	Hardy.	Hardy.				
176	Tartarian Maple	" Tartaricum.	Hardy (?)					
176	Horse Chestnut	Æsculus Hippocastanum	Not hardy	Too tender	Not hardy	Not hardy	Not hardy	
	Buckeye Chestnut.	Æsculus glabra	Not hardy	Too tender		Not hardy	Not hardy	
	Tree of Heaven	Ailanthus glandulosa	Very tender	Too tender		Not hardy	Not hardy	Tender
176	European Alder	Alnus incana	Hardy					
177	European Birch	Betula alba	Hardy	Hardy		Hardy	Hardy	Fair
177	Cut Leafed Birch	Betula alba, var. laciniata	Hardy	Hardy		Hardy	Hardy	Fair
177	Purple Birch	Betula alba, var. atropurpurea	Hardy	Hardy		Hardy	Hardy	Seems hardy
176	*Canoe or Paper Birch	Betula papyracea.	Hardy	Hardy	Hardy	Hardy	Hardy	
177	*Yellow Birch	Betula lutea	Hardy	Hardy		Hardy	Hardy	
177	American White Birch	Betula populifolia	Hardy	Hardy		Hardy	Hardy	
	Laburnum	Cytisus laburnum	Tender		Tender		Tender	
	*American Hornbeam	Carpinus Americana	Hardy	Hardy		Hardy		

177	*Bitternut Hickory	Carya amara	hardy	hardy		hardy	hardy	hardy
	Chestnut	Castanea Americana	not hardy	not hardy		not hardy	lasts a few years	not hardy
178	Hardy Catalpa	Catalpa speciosa	not hardy	not hardy		not hardy	not hardy	not hardy
178	*Hackberry or Nettle tree	Celtis occidentalis	hardy	hardy	one of our best lawn trees	hardy	one of our best trees	
	White Fringe	Chionanthus Virginica	very tender					
178	*Cockspur Thorn or Thorn Apple	Crataegus Crus-galli	hardy	hardy		hardy	hardy	
	American Beech	Fagus ferruginea	very tender	very tender			tender	
	European Beech	Fagus sylvatica	very tender	very tender				
179	*White Ash	Fraxinus Americana	hardy	hardy	not hardy	hardy	hardy	hardy
179	*Green Ash	Fraxinus viridis	hardy	hardy	hardy	hardy	hardy	
179	Honey Locust	Gleditschia tricanthos	very tender	very tender				tender
179	*Kentucky Coffee Tree	Gymnocladus Canadensis	hardy	hardy	hardy		hardy	all right
179	*Black Walnut	Juglans nigra	hardy in heavy soil	hardy in heavy soil	succeeds well in rich valleys here		hardy in heavy soil	fair
180	*Butternut	Juglans cinerea	hardy	hardy in heavy soil	hardy		hardy	first rate
180	European Larch	Larix Europea	hardy	hardy	short lived	hardy	hardy	hardy
180	*Tamarack	Larix Americana	hardy	hardy	short lived	hardy	hardy	inferior
	Tulip Poplar or White Wood	Liriodendron tulipifera	very tender			not hardy	not hardy	
	Osage Orange	Maclura aurantiaca	very tender	very tender		very tender	very tender	worthless
	Magnolia	Magnolias (species)	very tender			not hardy	not hardy	
	Russian Mulberry	Morus Siberica	very hardy		does well in some places	not hardy	valuable in places	tender
181	*Box Elder	Negundo aceroides	hardy	hardy	hardy	gen'ally hardy	hardy	hardy but not desirable

DECIDUOUS TREES.—CONTINUED.

Page	Common Name	Botanical Name	Experiment Station Notes	Wyman Elliott, Minneapolis	L. R. Moyer, Montevideo, Chippewa Co.	Prof. C. B. Waldron, Fargo	J. S. Harris, La Crescent, Minn.	E. H. S. Dartt, Owatonna, Minn.
181	*Ironwood	Ostrya Virginica	hardy	hardy	does well under cultivation	hardy	hardy	
181	White or Silver Poplar	Populus alba	hardy	hardy	hardy	hardy	hardy	hardy but a nuisance
182	Bolleana Poplar	Populus alba, var nivea	hardy	hardy			hardy	hardy
182	Lombardy Poplar	Populus fastigiata	short lived	short lived		often winter killed	Short lived	hot hardy
184	Russian Poplar	Populus Wobsky	hardy		doing well		hardy	
183	Russian Poplar	Populus certinencis	hardy	hardy	hardy		hardy	
184	Russian Poplar	Populus Siberica pyramidalis	hardy	hardy	hardy		hardy	
184	Russian Poplar	Populus betulif'lia	hardy	hardy	hardy		hardy	
184	Russian Poplar	Populus laurifolia	hardy	hardy	hardy		hardy	
183	Cottonwood	Popul's monilifera	hardy	hardy	hardy but kills out on dry ridges	hardy	hardy	a poor tree
182	Golden Poplar	Populus monilifera, var. Van Gerti	hardy					
184	*Black Cherry	Prunus serotina	hardy	hardy	hardy		hardy	hardy
184	*Choke Cherry	Prunus Virginica	hardy	hardy		very hardy	hardy	hardy
184	*Bird Cherry	Prunus Pennsyl'ia	hardy	hardy		very hardy	hardy	hardy
185	European or Mountain Ash	Pyrus aucuparia	very hardy	hardy	liable to sun scald	hardy	bardy	pretty good
185	*Native Crab Apple	Pyrus coronaria	hardy	hardy			hardy	hardy
185	Weeping Mountain Ash	Pyrus aucuparia, var. pendula	very hardy	hardy				
185	*American Mountain Ash	Pyrus Americana	very hardy	hardy		hardy	hardy	
185	Burr Oak	Quercus macrocarpa	hardy	hardy	best tree in West. Minn.	always hardy	hardy	hardy
186	*White Oak	Quercus alba	hardy	hardy	hardy	always hardy	hardy	hardy
186	*Red Oak	Quercus rubra	hardy	hardy				hardy
186	*Scarlet Oak	Quercus coccinea	hardy	hardy				hardy

186	Black or Yellow Locust	Robinia pseudo-acacia	nearly hardy	nearly hardy		not hardy	nearly hardy	not hardy
186	Maiden Hair Tree or Gingko	Salisburia adianti folia	quite hardy(?).					doubtful
188	Russian Willow	Salix acutifolia	hardy	hardy	doing well		hardy	hardy
187	Laurel Leaved Willow	Salix laurifolia	hardy	hardy	doing well		hardy	a fine tree
	American Weeping or Fountain Will'w	Salix purpurea, var. pendula	very tender	very tender			not hardy	
188	Royal Willow	Salix regalis	doing well					
187	Kilmarnock Weeping Willow	Salix caprea, var. pendula	very tender	very tender			not hardy	
187	Russian Golden	Salix aurea	hardy	hardy	doing well	hardy; will not stand drouth when grow'g	hardy	hardy
188	Napoleon's Willow	Salix Napoleonis	hardy	hardy			hardy	
187	Wisconsin Weeping Willow	Salix	very hardy	very hardy	succeeds here		doing well	desirable
186	White Willow	Salix alba	hardy	hardy	hardy	hardy	hardy	
188	*Basswood or American Linden	Tilia Americana	hardy	hardy	a fine tree	should be protected from wind	hardy	a fine tree
188	European Linden	Tilia Europea	not hardy					
189	*American or Wht. Elm	Ulmus Americana	hardy	hardy				
189	*Red or Slippery Elm	Ulmus fulva	hardy	hardy	hardy	hardy	hardy	hardy
189	Weeping Slippery Elm	Ulmus, var. pendula	hardy				hardy	
189	*Rock Elm	Ulmus racemosa	hardy	hardy	hardy	hardy	hardy	a fine tree
189	Camperdown Weeping Elm	Ulmus montana Camperdownii	hardy(?)				not hardy	

EVERGREEN TREES.

Page	Common Name	Botanical Name	Experiment Station Notes.	Wyman Elliott, Minneapolis	L. R. Moyer, Montevideo, Chippewa Co.	Prof. C. B. Waldron, Fargo.	J. S. Harris, La Crescent, Minn.	E. H. S. Dartt. Owatonna, Minn.
190	*Balsam Fir or Balsam	Abies, balsamea	hardy	hardy	doing well	hardy	hardy, but short lived	hardy, but short lived
190	Nordman's Fir	Abies, Nordmanianna	not hardy(?)					
194	*Red Cedar	Juniperus Virginiana	hardy	hardy	does well under cultivation	hardy	hardy	
196	*Trailing or savin Juniper	Juniperus sabina	hardy	hardy				
192	Norway Spruce	Picea excelsea	hardy	hardy	doubtful	hardy	hardy	a good tree
192	*White Spruce	Picea alba	hardy	hardy	doing well	hardy	a fine tree	all right
	Colorado Blue Spruce	Picea pungens	hardy	hardy	doing well	hardy		promising
192	*Black Spruce	Picea nigra	not desirable	hardy	a poor tree	hardy	hardy	
	Engleman's Spruce	Picea Englemanii	hardy(?)					
190	*White Pine	Pinus strobus	hardy	hardy	has failed here	hardy	a fine tree	a good tree
191	Scotch Pine	Pinus sylvatica	hardy	hardy	short lived, especially in dry places	hardy	a fine tree	very reliable
191	Austrian Pine	Pinus Austriaca	hardy	hardy			a poor tree	not very relia'le
191	*Red or Norway Pine	Pinus resinosa	hardy	hardy		hardy	hardy	a fine tree
192	Dwarf Pine	Pinus Mughus	hardy	hardy	our hardiest conifer	hardy	hardy	one of the best
191	Heavy Wooded Pine	Pinus ponderosa	hardy					
193	Douglas spruce	Pseudotsuga taxifolia	hardy	hardy				
194	Japan Cedar	Retinospora plumosa	not hardy					
196	*Arbor Vitæ or White Cedar	Thuja occidentalis	hardy	hardy		hardy	hardy	good
194	*Hemlock	Tsuga Canadensis	hardy	hardy				hardy when sheltered

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196	Aralia or Angelica Tree	Aralia Mandchurica	very hardy					
.....	Azalea	Azalea (species)	too tender					
.....	Althea, or Rose of Sharon	Hibiscus Syriacus	requires protection					
.....	American Box	Buxus (species)	too tender					
.....	Common or European Barberry	Berberis vulgaris	hardy	hardy				hardy
.....	Purple Leafed Barberry	Berberis vulgaris var.					hardy	hardy
.....	Thunberg's Barb'y	B. Thunbergii	hardy	hardy			ardy	
.....	Strawberry Shrub	Calycanthus flori-	unreliable					
.....	Sweet Pepper Bush	Clethra alnifolia	not hardy				hardy	
197	Siberian Pea Tree	Caragana arborescens	hardy	hardy	hardy		hardy	hardy
197	Red Twigged Dogwood	Cornus, sanguinea	hardy	hardy		hardy and desirable	hardy	
197	*Red Twigged Dogwood	Cornus, stolonifera	hardy	hardy		hardy and desirable	hardy	hardy
.....	Deutzia	Dentzia crenata	needs protection in winter	needs protection in winter				
.....	Deutzia	Deutzia gracilis	needs protection					
197	Weigela	Diervilla rosea	hardy (?)	hardy, in clay soil			hardy	
197	*Spindle Tree	Euonymus atropurpureus	hardy		very hardy		hardy	
198	Forsythia	Forsythia Fortunei	hardy (?)					
198	Hardy Hydrangea	Hydrangea paniculata grandiflora	hardy	hardy	not hardy		harrdy	
198	St. John's Wort	Hypericum aureum	hardy (?)					
198	St. John's Wort	Hypericum Kalmianum	very hardy					

ORNAMENTAL SHRUBS. CONTINUED.

Page	Common Name	Botanical Name	Experiment Station Notes	Wyman Elliott, Minneapolis	L. R. Moyer, Montevideo, Chippewa Co.	Prof. B. B. Waldron, Fargo	J. S. Harris, La Crescent, Minn.	E. H. S. Dart, Owatonna, Minn.
198	St. John's Wort	H. salicifolia	tender					
.....	Rose of Sharon	Hibiscus Syriacus	unreliable					
.....	Mountain Laurel	Kalmia latifolia	too tender					
198	Polish Privet	Ligustrum vulgare	unreliable	too tender				
199	California Privet	" ovalifolium	tender		tender			
.....	Privet	" from Poland	very hardy					
199	Tartarianc Honeysukle	Lonicera Tartarica	hardy	hardy	very hardy	hardy	hardy	
.....	Tartarian Honeysuckle	Lonicera Tartarica, var. splendeus	hardy	hardy	very hardy			
199	Syringa or Mock Orange	Philadelphus coronarius	hardy	hardy	very hardy		hardy	
199	Syringa or Mock Orange	P. grandiflorus	hardy	hardy	very hardy		hardy	
199	Syringa or Mock Orange	P. Gordonianus	hardy	hardy			hardy	
.....	Flowering Almond	Prunus Japonica	hardy ?					
199	*Nine Bark	Physocarpus opulifolius	hardy	hardy			hardy	hardy
199	Golden Spirea	Phys'carpus opulifolius, var. aurea	hardy	hardy			hardy	hardy
200	*Shrub. Cinquefoil	Potentilla fruticosa	hardy		does well here in dry soil		hardy	
.....	Trefoil or Hop Tree	Ptelea trifoliata	unreliable				hardy	
.....	Japan Quince	Pyrus Japanica	tender	tender			tender	
200	Common Buckthorn	Rhamnus Catharticus	hardy	hardy	hardy	hardy	hardy	
200	*Common Smooth Leafed Sumach	Rhus glabra	hardy	hardy		hardy		
200	Cut LeafedSumach	Rhus glabra, var. laciniata	very hardy			hardy		
200	Smoke Bush	Rhus cotinus	unreliable				fair	
.....	*Stag Horn Sum'h.	Rhus typhina	hardy				hardy	
.....	Rhododendron	Rhododen. species	too tender					

201	Yellow Flowering Currant	Ribes aureum	hardy	hardy	hardy	hardy	hardy	hardy
201	Alpine Currant	Ribes alpinum	hardy					
201	Gordon's Currant.	R. Gordonianum	unreliable					
202	*Common Elder	Sambucus canadensis	hardy	hardy		hardy	hardy	hardy
202	*Red Berried Elder	S. racemosa	hardy	hardy	hardy		hardy	hardy
202	Cut-Leafed Elder	S. nigra, var. aurea	very hardy	hardy				hardy
203	*Buffalo Berry	Shepher'a argenta	hardy	hardy	hardy	hardy	hardy	
202	V'n Houtte's Spira	Spirea, Van Houtti	hardy	hardy			hardy	
203		Spirea obovata	hardy	hardy				
203	Douglas' Spirea	Spirea Douglasi	very hardy	hardy			hardy	
203		Spirea lanceolata.	hardy	hardy			hardy	
203	Plum Leafed Spir'a	Spirea prunifolia	hardy	hardy				
203	Thunberg's Spirea	Spirea Thunbergii.	needs protec'on	not hardy				
203	Ash Leafed Spirea	Spirea sorbifolia	hardy	hardy		hardy	hardy	
203	Hypericum Leafed	S hypericifolia	very hardy		hardy	hardy(?)		
204	*Snowberry	Symphoricarpus	hardy			hardy	hardy	
204	Common Lilac	Syringa vulgaris	hardy	hardy		hardy	hardy	hardy
204	Persian Lilac	Syringa Persica	hardy			hardy	hardy	
204	Josika's Lilac	Syringa Josikæa	hardy			hardy	hardy	
205	*High bush Cranb'y	Viburnum opulus.	hardy	hardy		hardy	hardy	hardy
205	Snowball	V. op., var. sterilis	hardy	hardy		hardy	hardy	hardy
205	*Viburnum	Viburnum lentago	hardy	hardy	hardy		hardy	
205	*Viburnum	V. dentatum	hardy	hardy			hardy	
213	Adam's Needle	Yucca filamentosa	not hardy		not hardy	not hardy	not hardy	
205	*Prickly Ash	Zanthoxylum Am.	hardy	hardy	hardy	hardy	hardy	hardy

ORNAMENTAL VINES.

Page	Common Name	Botanical Name	Experiment Station Notes	Wyman Elliott, Minneapolis	E. R. Moyer, Montevideo, Minn.	Prof. C. B. Waldron, Fargo	J. S. Harris, La Crescent, Minn.	E. H. S. Dart, Owatonna, Minn.
206	*American Ivy	Akebia quinata	tender					
206	*Virginia Creeper	Ampelopsis Virginica	hardy	hardy	hardy	hardy and vigourous	hardy	
206	Japan or B'st'n Ivy	Ampelop's, Veitchii	not hardy..		winter kills			
207	Dutchmans' Pipe..	Aristolochia sipho	unreliable				fairr	
207	*Bitter Sweet	Celastrus scandens	hardy	hardy	very hardy	hardy	hardy	
207	European Sweet Clematis	Clematis flammula	not hardy				a	
207		Clema., Jackmanni	needs protection	needs protection	does well if protected in winter			
207		Clematis coccinea	needs protect'n					
207	*Virgin's Bower..	Clema. Virginiana	hardy	hardy	very hardy	hardy	hardy	
207		Clematis viticelli	hardy			hardy(?)	hardy	
207	*Honeysuckle	Lonicer, Sullivanti	hardy		hardy		hardy	
208	*Moonseed	Menispermum canadense	hardy	hardy	very hardy	hardy	hardy	
208	Wistaria	Wistaria (species)	unreliable..		completely winter kills..			
208	*Wild Grape	Vitis riparia	hardy	hardy	hardy	hardy	hardy	

HERBACEOUS PLANTS.

Page	Common Name Native plants of this state are starred.	Botanical Name	Experiment Station Notes	wyman Elliott, Minneapolis	L. R. Moyer, Montevideo, Chipyewa Co.	Prof. C. B. Waldron, Fargo	J. S. Harris, La Crescent, Minn.	E. H. S. Dart, Owatonna, Minn.
209	*Yarrow	Achillea millifolia	hardy	hardy	hardy	a pest	hardy	
209	Double White Y.	Achillea ptarmica, var. fl. pl.	hardy	hardy	hardy			
209	Columbine	Aquilegia in var.	hardy	hardy	hardy	hardy	hardy	
209	Hollyhocks	Althea rosea, var.	hardy if prot'd	hardy if prot'd	winter protec'n		requires prot'n	
209	Reed	Arundo donax	hardy if heavily protected	not hardy			not hardy	
209	Variegated Reed	Arundo, var.	"	not hardy			not hardy	
208	*Milkweed	Asclepius incarna'a	hardy	hardy	hardy	hardy	hardy	
209	Milkweed	Asclepius tuberosa	hardy	hardy	hardy	hardy	hardy	
209	*Hardy Asters	Aster (species)	hardy	hardy	hardy	hardy	hardy	
210	Bocconia	Bocconia cordata	does best when protected					
210	Lily of the Valley	convallaria maj'lis	hardy	hardy			hardy	
210	Coreopsis	Coreop. lanceolata	hardy	hardy	hardy	hardy	hardy	
210	Larkspur	Delphinium (perennial)	hardy				hardy	
210	Bleeding Heart	Dicentra spectabilis	hardy	hardy	hardy	hardy	hardy	
210	Gas Plant	Dictamnus fraxinella	not hardy					
210	Pampas Grass	Erianthus ravennæ	not hardy					
210	Eulalia	Eulalia zebrinum	not hardy unless protected					
223	Eulalia	Eulalia versicolor.	"					
2 3	Eulalia	Eulalia gracillima	"					
211	Funkia	Funkia cærulea	"					
211	Baby's Breath	Gyphsophila paniculata	hardy	hardy	hardy (?)			

HERBACEOUS PLANTS.—CONTINUED.

Page	Common Name	Botanical Name	Experiment Station Notes	Wyman Elliott, Minneapolis	L. R. Moyer, Montevideo, Chippewa Co.	Prof. C. B. Waldron, Fargo	J. S. Harris, La Crescent, Minn.	E. H. S. Dart, Owatonna, Minn.
211	Perennial Double Sunflower	Helianthus Multiflorus, fl. pl.	unreliable	unreliable				
211	Fleur de Lis	Iris Germanica	hardy	hardy		hardy	hardy	
211	Poker Plant	Kniphofia aloides	not hardy					
	Pæonies	Pæonies in var.	hardy	hardy	hardy			
211	Mountain Fleece	Polygonum	hardy	hardy			hardy	
212	Phlox Perennial	P. decussata var.	hardy	hardy				
212	Ribbon Grass	P. arundinacea	hardy	hardy			hardy	
212	Pyrethrum	Pyrethr., roseum.	hardy	hardy			hardy	
212	Meadow Sweet	Spirea Japonica	hardy		winter kills			
212	Tansy	Tanacetum	hardy	hardy	hardy	hardy	hardy	
213	*Spider Wort	Tradescantia Virginica	hardy		hardy	hardy	hardy	
213	Pansy	Viola tricolor	requires protection	requires protection				
213	Adam's Needle	Yucca filamentosa	unreliable	not hardy	winter kills completely			

SELECT SHORT LIST OF TREES, SHRUBS AND HERBACEOUS PLANTS.

The shrubs and plants in this list are selected as being those most desirable for general street, lawn and park purposes in Ramsey and Hennepin counties and vicinity, and by the use of the table of hardiness the list can be easily adapted to any part of the state.

LARGE DECIDUOUS TREES.

Common Name.	Botanical Name.
*American Elm	*Ulmus Americana.*
*Hackberry	*Celtis Occidentalis.*
*Basswood	*Tilia Americana.*
*Soft Maple	*Acer dasycarpum.*
*Box Elder	*Negundo, aceroides.*
*White Ash	*Fraxinus Americana.*
White Willow	*Salix alba.*

SMALL DECIDUOUS TREES.

*Paper Birch	*Betula papyracea*
Cut-leafed Weeping Birch	*Betula alba var.*
Upright White Poplar	*Populus Bolleana.*
European Mountain Ash	*Pyrus aucuparia.*
Laurel-leafed Willow	*Salix lauriflora.*
Oil berry	*Elæagnus angustifolius.*

EVERGREENS.

*White pine	*Pinus strobus.*
*Red pine	*Pinus resinosa.*
Scotch pine	*Pinus sylvestris.*
Dwarf pine	*Pinus mughus.*
*White Spruce	*Picea alba.*
Norway spruce	*Picea excelsa.*
*Red cedar	*Juniperus Virginiana.*

ORNAMENTAL SHRUBS.

*Red twigged dogwood.....*Cornus stolonifera.*
Hardy hydrangea.....*Hydrangea paniculata grandiflora.*
Tartarian honeysuckle.....*Lonicera Tartarica.*
Syringa.....*Philadelphus*, in variety.
Golden spirea.....*Physocarpus opufolia, var. aurea.*
Buckthorn.....*Rhamnus catharticus.*
Japanese rose.....*Rosa rugosa.*
Missouri currant.....*Ribes aurea.*
Spirea, L. Van Houtte.....*Spirea Van Houttei.*
Ash leafed spirea.....*Spirea sorbifolia.*
Spirea.....*Spirea obovata.*
*Buffalo berry.....*Shepherdia argentea.*
Lilac.....*Syringa vulgaris*, in variety.
*High bush cranberry.....*Viburnum opulus.*
*Snowball.....*Viburnum opulus, var.sterilis.*

HERBACEOUS PLANTS.

Columbine.....*Aquilegia vulgaris.*
Lily of the valley.....*Convallaria majalis.*
Larkspur.....*Delphinium hybridium.*
Bleeding heart.....*Dicentra spectabilis.*
Baby's breath.....*Gypsophila paniculata.*
German iris.....*Iris Germanica.*
Colored daisies.....*Pyrethrum roseum.*
Herbaceous peonies.....*Pæonia sp.*
Double yarrow.....*Achillea ptarmica, flora plena.*

VINES.

*Virginia creeper.....*Ampleopsis Virginica.*
*Bitter sweet.....*Celastrus scandens.*
*Virgin's bower.....*Clematis Virginiana.*
*Wild grape.....(staminate form).....*Vitis riparia.*

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EXLANATION OF SIGNS AND ABREVIATIONS.

Trees native to the state are starred thus *.

The question mark (?) following a note on a variety indicates that the kind has not been long enough tried to warrant ultimate conclusions or that the observation may need to be modified.

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UNIVERSITY OF MINNESOTA.

Agricultural Experiment Station.

BULLETIN No. 25.

HORTICULTURAL DIVISION.

DECEMBER, 1892.

REPORT ON SMALL FRUIT. NOTES FROM TRIAL STATIONS.
NOTES ON RENEWING OLD STRAWBERRY BEDS.
SHADING STRAWBERRY BEDS. SEEDLING FRUITS.
ANALYSES OF GRAPES. SPRAYING GRAPE VINES.

☞ The Bulletins of this Station are mailed free to all residents of the State who make application for them.

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VETERINARIA

The season of 1892 like that of 1891 has been an excellent one for small fruit crops. It is the object of this bulletin to discuss the merits of new and old varieties of interest that have fruited in this state the past season.

STRAWBERRIES.

Strawberries were a fair crop; prices were higher than for several years, and the abundant rains have put the young plantations in the best of condition for a good crop next year. The leaf blight was very destructive to some varieties, notably the well known Captain Jack, which has been very generally a failure from this disease. Our experience at the experiment station goes to show that while it is possible to keep most varieties healthy by the use of Bordeaux mixture and other fungicides, yet it is much better to plant varieties that resist this disease. It is very certain that only healthy varieties can produce paying crops of fruit, and while the health and productiveness of varieties o the strawberries vary much on different locations, yet some varieties do remarkably well over a large area and in almost any location or soil.

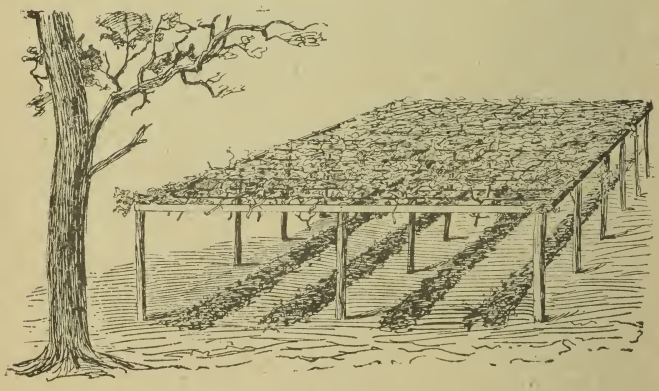
The strawberries at the experiment station are on open clay land having a gentle slope to the south, and are grown in the matted row system. The runners are allowed to root until the row is well filled, and any that start afterwards are cut off. It is our practice to fruit strawberry beds a second time if they are in good condition when the first crop is gathered, and this year most varieties have proved more prolific on old beds than on the new. In renewing old strawberry beds the following plan is pursued:—

RENEWING OLD STRAWBERRY BEDS.

As soon as may be after the crop is gathered the bed is closely mowed and all the weeds and strawberry leaves are

burned. A plow is then run on each side of a matted row and all but about one foot in width of it is turned under. The furrows thus made are filled with fine rotted manure and the cultivator set going*. The plants remaining are then thinned out with a hoe and special pain is taken to cut out all weeds and old or weak plants. This leaves the old bed clean, with plenty of manure close by, in which the old plants can make new roots. The plants soon send up new leaves which are much healthier than they would be were the old foliage allowed to remain, and if we have an ordinary season an abundance of runners will be sent out and by winter the old bed will look nearly as vigorous as a new one. At the time of this writing we have an old bed of various kinds that has borne two crops, which we cleaned up in July for a third, and it is very difficult to find on it a single diseased leaf among the several varieties with which it is planted, and the rows are full of green, vigorous plants and runners.

SHADING STRAWBERRY BEDS.



Showing brush screen used for shading strawberry bed; placed six feet from ground.

Many complaints have reached us of the difficulty of securing a good crop of strawberries in exposed places on the prairies, even when the plants had grown well and both staminate and pistillate kinds were planted. This trouble is

*We sometimes find it necessary to take out all but the two outside cuultivator teeth if the mulch is very thick.

probably due to the pollen being too much dissipated by the wind, and further to the drying up of the fruit after it is set by the hot sun and winds. With the object of finding a remedy for this trouble some preliminary experiments have been undertaken, in one of which a part of the strawberry bed, including mostly plants of a late variety, named Parker Earle, was shaded with a brush screen, such as we use for protecting evergreen seedlings, and as shown in the cut herewith. The result was that the plants under the screen matured all the fruit, while on those not thus shaded many berries were sun scalded and many others failed to ripen. In the first case we had a full crop; in the second perhaps one-half. This is confirmatory though not by any means conclusive data on which to recommend this practice to those wishing to grow strawberries in very exposed places. But it would seem, however, a very rational suggestion when we remember that generally the best fruit, and certainly the best late fruit of strawberries is found in the wild ssate in locations somewhat protected and shaded and that in such places the foliage is seldom affected with fungous diseases. The past season was in point of moisture an exceptional one and not the best in which to make this trial.

A good screen for this purpose is made by setting posts with natural crotches in one end connected together by poles and covered with willow or other brush sufficient to give a play of light and shadow on the bed, but not enough to keep out more than half the sunlight. I think it would be well to have such a bed in a somewhat protected location. Such treatment might not be practicable on a large scale, but it is so very inexpensive and simple that it is well worth trying in a small way in the home garden. We shall report further on the matter when we have more fully investigated it, and make this simply as a report of progress and as a suggestion to fuit growers.

SEEDLING STRAWBERRIES.

For fruiting next year we have a fine lot of about seven

(700)hundred seedling plants that we have kept the runners off, and they are very promising indeed; They are seedlings of Warfield and Haverland, fertilized with Michels' Early.

From seed sown this year we have over two thousand plants pricked out in frames, which we expect will be in excellent condition to plant out next spring. These are the result of carefully made crosses between our most prolific kinds.

*In the table herewith, varieties marked (p) have pistillate flowers. Those marked (b) have bi-sexual or perfect flowers. Varieties mentioned but with columns not filled out are not considered worthy of more than passing notice.

*Especially desirable kinds are starred.

STRAWBERRIES.	Origin	Date of Blooming	Date of first Picking	Diameter first Picking	Date of Last Picking	Quality (scale 0-10)	Firmness (scale 0-10)	Value for Market (scale 0-10)	Vigor (scale 0-10)	Productiveness (scale 0-10)	General appearance (scale 0-10)	Rust (scale 6-10)	REMARKS.
Atlantic (b)	Ont.	.....	July	....	.....	.....	.....	.....	.....	.....	.....	.....	Not worthy of notice.
Belmont (b)	Mass.	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	1	" " "
Beder Wood (b)**	Ills.	6-11	7-3	1	7-16	7	7	.....	8	8	.....	2	A promising variety.
Bubach (b)	Ills.	6-11	7-5	1¾	7-14	9	8	9	7	8	10	0	Very large but not very productive.
Boynton (p)	N. Y.	6-9	7-7	1	.....	7	9	9	10	7	10	1	Worthy of further trial.
Crescent (p)**	Conn.	6-9	7-3	1	7-17	5	10	9	10	8	10	0	Well known and valuable.
Crawford (b)	Ohio	6-10	7-5	¾	7-13	8	9	.....	10	6	10	2	A handsome fruit but not prolific.
Cloud (p)	La.	6-14	.....	....	7-13	8	.....	.....	.....	.....	.....	0	Worthless here.
Captain Jack*	Wis.	6-9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Ruined by rust.
Daisy (p)	Ohio	6-12	7-6	1¼	7-20	.....	8	.....	8	6	10	0	Not promising but shall try it another year.
Eureka (p)	Ohio	6-17	7-9	1	.....	7	8	6	10	5	8	4	Shall discard it.
Enhance (b)	Ohio	6-10	7-6	1¼	7-16	9	9		7	7	10	1	From August set plants; worthy of further trial.
Farnsworth (b)	Ohio	6-12	7-7	¾	.....	9	8	3	8	3	6	2	Not promising.
Great Pacific (p)	Ills.	6-12	7-7	1¼	7-17	7	8	8	9	8	8	2	Berries very small after first picking.
Gov. Hoard (b)	Wis.	6-11	7-7	1¼	.....	7	8	7	7	5	7	2	Not productive enough.
Gandy	N. J.	6-16	7-12	1¼	.....	8	8	8	.....	.....	.....	.....	Valued for its lateness.
Haverland (p) ***	.....	6-9	7-3	1¼	7-16	10	7	10	8	10	10	0	A valuable variety for home or market.
Jessie (b)	Wis.	.....	.....	....	7-13	.....	.....	.....	.....	.....	.....	.....	Too uncertain; a failure this year.
Lady Rusk (p)	Ills.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Worthless from rust.
Louden's15 (b)	Wis.	6-10	7-6	....	7-16	5	7	7	9	8	.....	1	Worthy of trial.
Lovett's Early (b)	Ken.	6-12	7-10	¾	.....	7	8	.....	.....	4	.....	2	Not promising.
Middlefield (p)	.....	6-13	7-7	¾	7-16	8	9	4	7	6	8	0	A weak grower, not very productive.
Michel's Early* (p)	Ark.	6-9	7-1	1	7-13	10	10	10	10	7	6	0	Valuable as a pollenizer.
Martha (p)	Minn.	6-14	7-13	1⅛	.....	.....	.....	.....		.....	.....	.....	Not valuable here.
Mammoth (b)	.....	6-12	7-13	1½	.....	8	8	7	9	6	8	2	Produces a few large berries.
Seedling No. 17 (p)	Ky.	6-13	7-5	1⅛	.....	8	8	8	10	9	9	1	Worthy of a name.

STRAWBERRIES	Origin	Date of Blooming	Date of First Picking	Diameter, First Picking	Date of Last Picking	Quality (scale 0-10)	Firmness (scale 0-10)	Value for Market (scale 0-10)	Vigor (scale 0-10)	Productiveness (scale 0-10)	General Appearance (scale 0-10)	Rust (scale 0-10)	REMARKS.
Great American (p)	.. ....	6-13	7-7	1¾	7-17	8	8	6	8	5	10	1	Not productive enough.
Little's Seedling No. 37 (p). ...	Ont.	6-13	7-8	1¾	.....	.....	7	8	.....	9	10	2	Resembles the Warfield.
Little's Seedling No. 7 (b)	Ont.	6-12	7-7	1¾	.....	8	8	0	10	9	10	½	Very distinct; dark foliage.
Little's Seedling No. 9 (p)	Ont.	6-11	7-9	1¾	.....	7	8	.....	9	6	9	0	A very promising seedling.
Mrs. Cleveland.....	Ohio	6-12	7-13	1⅛	.....	7	8	5	10	8	8	.....	A promising variety.
Oliver (p)	Ills.	.....	7-7	¾	.....	9	9	.....	10	3	2	1	Worthless; almost barren.
Osaola (p).....	Ark.	.....	.....	.....	.....	.....	.....	9	.....	.....	.....	.....	Same as Michael's Early.
Oregon Everbearing[b].....	Ore.	6-10	7-5	¾	7-16	9	8	8	.....	4	8	0	Not everbearing, at all.
Park beauty (p).....	.....	6-11	7-7	....	7-15	9	7	8	10	6	9	2	Not reliable; inclined to rust.
Parker Earl,(shaded)(b).....	Tex.	6-12	7-11	1⅛	7-25	9	9	.....	10	7	10	0	Worthy of general trial.
Pearl (b)	N. J.	6-9	7-4	1¼	7-20	9	9	8	7	8	10	1	A promising kind.
Princess (p).....	Minn.	6-13	7-6	1¼	7-16	10	7	10	7	7	9	.....	Valuable for near market
Saunders (b).....	Ont.	6-16	7-6	....	.....	.....	.....	8	.....	.....	.....	.....	Not productive.
Schuster's Gem (p).....	N. J.	6-12	7-6	1½	7-17	9	6	7	9	8	9	2	A large productive kind.
Tippecanoe (b).....	Ind	6-13	7-7	¾	7-19	9	8	0	9	1	1	2	Ruined by rust.
Van Deman (b).....	Ark.	6-11	.....	....	.....	.....	.....	.....	.....	.....	.....	10	Seriously injured by rust.
Wolverton (b).....	Ont.	6-18	7-6	¾	.....	.....	.....	.....	.....	.....	.....	.....	Ruined by rust.
Wilson (b)	N. Y.	6-11	7-7	1	.....	8	10	8	6	6	9	1	Well know.
Warfield (b)***.....	Ills.	6-12	7-2	1	7-16	7	9	10	10	10	.....	0	One of the best.
Yale (b).....	Conn.	6-14	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	Not worthy of mention.

†Varieties especially desirable are marked by *, ** or ***, according to their value for general planting.

NOTES ON VARIETIES.

Especially desirable kinds are starred.

Beder Wood. (b)** A very promising new berry that has done remarkably well with us this season. It is bi-sexual, has lots of pollen and I think it well worth trying as a pollenizer and for market. Its foliage is only slightly affected with rust.

Bubach. (p) Gave us a few magnificent berries but not enough to make a profitable crop.

Boynton. (p) Is a red berry of about the size and with much the appearance of the Crescent, but apparently no better.

Crescent. (p)** This old standard variety has done very well this season. In our old bed it produced a far larger crop than in the new bed, but it did not do nearly as well as the Warfield, which I think is generally superseding it.

Captain Jack. (b)* Was nearly ruined by rust.

Great Pacific. (b) I am somewhat disappointed in this variety. Some of the fruit is large, but much of it is small and irregular in shape and rather inclined to rust.

Haverland. (p)*** Has done much better than last year, and was in many ways our best berry. The foliage is healthy and the berries are elegant. It produced rather more fruit this year than the Warfield.

Jessie. (b) Was nearly a failure with us this year, as well as at some of our trial stations. I regard it as a very uncertain kind and think there is a weakness in the blossoms that makes it peculiarly susceptible to injury from winds, frosts and heavy rains.

Michel's Early. (b)* I think well of this variety as a pollen producer, but it does not produce much fruit and has not been as productive this year as last. Yet the fruit this

year was rather larger and better in quality than last. I mean to continue using it as a pollen producer. It is a vigorous grower and free from rust.

Little's No. 7. (b) From John Little, Granton, Ont. Is one of the most striking in foliage and fruit of any that has come to my notice for several years. The foliage is tall, dark green and very healthy. The fruit is long, large and firm, on long peduncles. Very productive and a promising late fruit.

Little's No. 9. (p) Also from John Little. Is a very productive and promising variety of large size.

Little's Seedling No. 37. (p) Resembles the Warfield very much but it is not quite as early and is somewhat sweeter. Very productive and promising.

Lovett's Early. (b) Is a berry of good color, form and substance, but not sufficiently productive to be profitable.

Enhance. (b) Has produced some very good fruit on August set plants but needs another season's trial to thoroughly test it. Promising.

Oregon Everbearing. Whatever everbearing qualities it may once nave had it does not show them here and I rather doubt that it ever bore over any number of consecutive seasons more than one crop a year. Not desirable.

Parker Earle. (b) Is about ten days behind the Warfield. It has a great lot of green fruit but during the hot weather much of it fails to ripen satisfactorily. This year a part of the space devoted to it was shaded, with the result that the portion so treated produced a fine crop of fruit, while the rest gave a very light crop after the first picking. Plant very healthy and vigorous, but it does not make many runners.

Princess. (p) Seems to be doing better in the hands of its originators and elsewhere than with us. I regard it as generally a profitable berry for the near market. It is of large size and fine color, but rather soft.

The Pearl. (b) A beautiful bright red berry that did poorly with us last year but this year is very productive.

Schuster's Gem. (p) Did remarkably well with us last year but not so well this. It is of good size and worthy of further trial.

Saunders. (b) Did very well with us last year but this season seems much inclined to rust.

Warfield.(p)*** Is the most popular berry grown and is fast supplanting the Crescent in this state. It is a better shipping and selling berry than the Haverland. Our customers especially like it for canning purposes.

List of new varieties planted the spring of 1892:

Accomack	Beverly	Swindle
Edgar Queen	Waldron	Southard
Standard	Putnam	Stevens
Gillespie	Westlawn	Williams
Muskingum	Auburn	Dayton
Noble	E. P. Roe	Mark
Leader	Gem	Waupon
Ona	Oscar	Sandova

RASPBERRIES.

The raspberry crop has been a very profitable one this easson. Almost every variety has given good returns. Many plantations of red raspberries are affected with the disease commonly called "leaf curl," and it is becoming a very serious matter in many places where it is spreading slowly but surely. No remedy is known for the disease, but the best treatment for it seems to be the digging out and burning of all affected plants. In starting a new bed it should be only on new land and great care should be taken to use only healthy plants.

SEEDLING RASPBERRIES.

About five hundred seedlings of Schaffer's Collossal fruited this year for the first time. The fruit resembles very closely that of the parent plant, and a number of seedlings ap-

peared fully as valuable as that of the Schaffer. Fifty of these were selected as being worthy of further trial It is a point of special interest that the seedlings of this variety, which is generally termed a hybrid should be so uniform and show so much of a fixed type.

NOTES ON SOME OF THE NEW RASPBERRIES.

NATIVE RED RASPBERRIES.—(*Rubus Strigosus.*)

Especially desirable kinds are starred.

Brandywine.** Is very popular in very many trying locations. A valuable shipping sort.

Cuthbert.*** The most popular of the red raspberries. Large, firm, productive and very hardy.

Gladstone. Grows vigorously and produces a little fruit until frost, but what little fruit it does produce is so small and soft as to make it almost worthless either for home use or for mrrket.

Golden Queen.** Continues to be the favorite yellow kind. Its fruit is large and firm. With the exception of color, practicaliy identical with Cuthbert.

Hansell.* A very early kind that is becoming quite a favorite. It is a rather weak grower, except on rich soils, and until well established it needs high cultivation.

Marlboro.** Where this variety gets high cultivation on clay soils it is generally successful. Its large fruit is handsome and though of rather poor quality, brings the highest price in the market.

Turner.* A well known, very popular old variety. Early but very soft; generally prolific and hardy. Not much planted for several years.

RUBUS NEGLECTUS

Caroline. Quite soft but very prolific and very hardy. It succeeds well when most kinds fail. Yellow.

Schaffer.** Where its color is not objectionable it is a very profitable kind to grow for the near market. Purple in color.

EUROPEAN RED RASPBERRIES.—(*Rubus Ideas.*)

Superlative. A new variety sent out by Ellwanger & Barry of Rochester, New York, at six dollars ($6) per dozen in 1892. Fruit on spring set plants very large but crumbly and of poor quality. Foliage and cane of the Antwerp type.

Champlain. Similar to the above in foliage and cane, but has not fruited here.

BLACK CAP RASPBERRIES.—(*Rubus Occidentalis.*)

Kansas. A very vigorous and productive variety from Kansas. Fruit large, of fine appearance and very promising.

Lovett, or ($1000). Will probably prove to be a desirable addition to our list of second early kinds. The fruit is as large as the Gregg and it is several days earlier. Foliage and cane quite distinct

Mystery. Sent out from Kentucky as an everbearing kind. It bears but one crop here.

Nemaha.*** Is without doubt somewhat hardier than the Gregg and so much alike it in fruit as to be practically the same thing for marketing purposes.

Older. We have not fruited this variety, but reports on its behavior elsewhere convince me that it is well worthy of trial by berry growers. Season about with the Ohio.

JAPAN RASPBERRIES.—(*Rubus Japonica.*)

Japan Wineberry. This berry has been greatly misrepresented and is giving very general disappointment where tried. It is interesting to botanists and may be useful in hybridization, but for fruit production it is practically worthless. The berry is small, of poor color and enclosed in a husk like a ground tomato.

Varieties of raspberries planted at experiment station in 1892:

Thompson's Early Prolific — Superlative
Brackett's Seedling, 101
Champlain — Older — Ada

NATIVE AMERICAN VARIETIES. (*Rubus Strigosus.*)

INCREASING BY SUCKERS.

RASPBERRIES.	Origin.....	Date of first Picking.....	Size (scale 0-10).....	Quality (scale 0-10)..	Firmness (scale 0-10)	Value for maket (scale 0-10.....	Vigor (scale 0-10).....	Productiveness (scale 0-10)	General Appearance (scale 0-10).....	Color of Berry	REMARKS.
Brandywine**.....	.....	7-18	6	6	10	9	10	9	8	red	Is doing finely in many places.
Cuthbert.....***	N. Y.	7-20	10	10	9	10	10	10	10	red	The most popular of the reds.
Golden Queen**.....	N. J.	7-27	10	10	9	10	10	10	10	yellow	The best yellow berry.
Gladstone.....	Ohio	7-25	2	6	5	4	10	5	5	red	Almost worthless.
Hansell*.....	N. J.	7-14	6	7	8	9	8	9	10	red	A fine bright red early kind.
Marlboro**.....	N. Y.	7-16	10	6	10	10	7	10	10	red	In favorable locations very profitable.
Turner*.....	Ills.	7-16	7	10	6	8	10	10	8	red	A robust early kind.

EUROPEAN RASPBERRY. (*Rubus Ideus.*)

Superlative.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		(Spring-set plants.) Fruit large, crumbly.
Superb.....	N. J.	.....	.....	.....	.....	.....	.....	.....	.....		Crumbles badly in picking.

RUBUS NEGLECTUS.

Caroline.....	N. Y.	7-9	7	8	5	8	8	9	6	yellow	Very hardy. Succeeds where many kinds fail.
Reliance.....	N. J.	7-13	8	7	9	10	3	9	9	red	Well worthy of trial.
Schaffer**...	N. Y.	7-19	9	9	7	6	10	10	10	purple	One of the most prolific.

BLACK CAP RASPBERRIES. (*Rubus Occidentalis.*)

NATIVE AMERICAN TIP ROOTING VARIETIES.

RASPBERRIES.	Origin.....	Date of First Picking.....	Size (scale 0-10).....	Quality (scale 0-10)..	Firmness (scale 0-10)	Value for Market scale 0-10	Vigor (scale 0-10).....	Productiveness (scale 0-10).....	General Appearance (scale 0-10).....	REMARKS.
Cromwell	Conn.	7-16	8	9	7	9	9	9	9	A worthy new early variety.
Conrath's Early	Mich.	7-16	6	8	9	8	7	8	8	A new early promising kind.
Gregg***	Ind.	7-20	10	6	10	10	10	10	10	Well known and popular.
Hopkins	Mo.	7-16	7	7	9	9	8	8	9	Generally productive.
Kansas	Kan.	7-19	9	8	10	9	9	9	10	A new kind of great promise.
Lovett's	.....	7-17	9	8	10	9	10	9	10	Distinct foliage, very promising.
Mystery	Ky.	7-22	7	8	8	8	8	3	9	Sent out as an everbearing variety.
Nemaha ***	Neb.	7-21	10	6	10	10	10	10	10	I think it maysupplant the Gregg.
Ohio***	N. Y.	7-18	6	8	9	8	10	10	10	A well known and valuable second earlykind
Progress	.....	7-13	...	7	8	8	9	8	7	Similar to Souhegan.
Palmer	Ohio	7-15	7	7	9	8	9	9	9	Similar to Souhegan.
Souhegan **	N. E.	7-14	6	8	10	10	9	9	8	A popular early kind.
Tyler	.....	7-14	6	9	9	9	9	9	8	Practically the same as Souhegan.
Older	Ills.	.....	...	...	...	...	...	...	...	Probably valuable as sccond early.

JAPAN RASPBERRY. (*Japonica Rubus.*)

Japan Wineberry	Japan	8-16	4	3	10	0	10	6	4	Of no value for fruit.

Espccially desiiable varieties are marked * ** or *** according to their value.

BLACKBERRIES AND DEWBERRIES.

The **Ancient Briton** blackberry has done the best of any tried at the Experiment Station, and is generally more satisfactory in this state than any other variety, but some growers are more successful with the Snyder which ripens earlier but is rather more difficult to protect on account of its stiff canes

The **Stones hardy** is not generally as prolific or as desirable as either of the above.

The **Agawam** has been very productive at the Experiment Station and we regard it as a good berry.

Early Harvest has proven a total failure at the Experment Station, as we have never been able to winter the canes even when laid down and covered with soil.

Jewett is a new blackberry received from the J. C. Lovett & Co., Little Silver, N. J., in 1890. It killed with us the first year although well protected with soil.

El Dorado is a new blackberry that we received from Greenville, Ohio, in 1891. It was quite prolific this season, of good, large fruit. A promising kind.

DEWBERRIES.

We have grown the Lucretia and the Windom dewberries several years and are certain we have them true to name, but they have proven nearly a total failure. They bloom profusely, have sometimes given us a few good berries, but the fruit almost without exception is imperfect. There may be isolated locations where they can be grown to advantage. They generally do best on sandy soil.

REPORT ON GRAPES.

We have two vineyards at the Experiment Station—one with an easterly and the other with a southerly aspect. The fruit on the south slope is generally ripe about six days earliyr than that on the eastern slope. In the table herewith the periods of ripening given are from observations made in the vineyard on the south slope. The ten (10) varieties that have given us the most grapes of good table quality in the past five years, arranged nearly in the order of their value, are: Concord, Worden, Aminia, Hartford, Brighton, Herbert Barry, Lindley, Moor's Early, and Lady. For severe locations the Janesville is very satisfactory on account of its hardiness and reliability, but its quality is very poor.

MULCHING GRAPE VINES.

When I took charge of the horticultural work at the Experiment Station in 1888, I found there a young vineyard of about four hundred (400) vines growing thriftly on the south side of a rather gravelly knoll. The very dry spring of 1889 seriously crippled it and occasionally heavy rains washed it badly. To overcome this difficulty I mulched it the following winter with bedding litter to the depth of about four inches, covering all the land. The result of this was very marked the following year when the vines ripened up their fruit in excellent condition and also made a fine well ripened growth of wood. Last spring the land was well cultivated and again mulched with equally good results which appear at this writing. On the whole I am much pleased with the outcome of this simple experiment. But it should be born in mind that in this trial the soil was light, loose and warm and probably equally good results would not be obtained on cold soils. One effect of the mulch on the soil was to change it in one season from a mineral soil that would easily wash away in heavy rains, to one resembling new timber land.

SPRAYING OF GRAPE VINES.

This season mildew of grapes (*Poronospora viticola*) has been very abundant so that Delaware and other varieties with weak foliage have in many cases been severely injured and the crops a total loss. When vines drop their vines prematurely not only is the crop of fruit for that season ruined but the wood often does not ripen and in consequence the crop of the following year may be a poor one. But this disease may be surely prevented by the use of proper fungicides. However it will not do to wait until the disease shows itself for then it is too late for any application to do much good.

The following letter from a graduate of the Farm School of the University of Minnesota, giving his experience this year in spraying the vineyard of Mrs. Erwin of Excelsior, will probably be read with much interest by grape growers. It should be said in explanation that his neighbors who did not spray their Delaware vines either lost their entire crop of fruit or had it seriously injured by the mildew, while the sprayed vineyard matured a very heavy crop of Delawares, Concords and other kinds.

EXCELSIOR, MINN., OCTOBER 21st, 1892.

PROF. SAMUEL B. GREEN, St. Anthony Park, Minn.

Dear Sir:—At your request I give the following account of my experience in spraying grape vines for mildew the past season.

A close observer by the aid of a microscope might easily have seen mildew on the leaves of the Delawares when they were not larger than a silver dollar. When the leaves were of this size I commenced spraying them and continued doing so at intervals of twelve or fifteen days until the latter part of July—spraying five times in all.

The Concords were sprayed but twice. I used the Bordeaux mixture the first three times on the Delawares and the first time on the Concords. For the other sprayings I used the ammoniacal solution of carbonate of copper. Several other varieties were treated the same as the Concords, but it is my opinion that most of them would have been freer from the brown rot if they had been sprayed oftener.

To prepare the Bordeaux mixture I dissolved six pounds of sulphate of copper in five gallons of water and slacked four or five pounds of lime in enough water to make a thick whitewash. In order to allow the copper sulphate to dissolve and the lime to slack, I did this a few hours before mixing the two. I put the copper solution in a fifty gallon kerosene barrel and

strained the whitewash into it, through a course sack and added enough water to fill the barrel.

I made the ammoniacal solution by dissolving five ounces of carbonate of copper in three pints of ammonia and stirring it into fifty gallons of water.

The Concords and Delawares each took fifty gallons the first time and one hundred gallons each time thereafter.

I used an Excelsior knapsack sprayer which worked very well. It cost $12.50. The cost of spraying nine hundred Delaware vines five times and twelve hundred Concords twice, is shown below:

On the Delawares I used—

1st time, 6 lbs. copper sulphate @ 7c		$ .42
2nd and 3rd times, 24 lbs. copper sulphate @ 7c		1.68
4th and 5th times,	20 oz. carbonate of copper @ 4c	.80
	12 pts. ammonia @ 25c	3.00
Total cost of material for Delawares		$5.90

These vines yielded 6,800 pounds of grapes or on average of 7 5-9 pounds per vine.

With the Concords the account stood as follows:

1st time, 6 lbs. sulphate of copper @ 7c		$ .42
2nd time,	10 oz. carbonate of copper @ 4c	.40
	6 pts. ammonia @ 25c	1.50
Total cost of material for Concords		$2.32
Total cost of material for Delawares and Concords		$8.22
Total cost of labor 4½ days @ $1		4.50
Total cost of labor and material for spraying		$12.72

Yours truly, F. F. PRATT.

In addition to the above it should be said that this has been an unusally bad season for mildew but had we had very bright, dry weather after the first spraying with Bordeaux mixture the second spraying with it might have been dispensed with without loss, however, it will always be found safer to spray once too often than to lack one spraying of destroying the mildew.

ANALYSES OF GRAPES.

Professor H. Snyder has made the following analyses of grapes grown at the Experiment Station which will be of interest to many.

The total sugar includes both grape and fruit sugar as determined by Felbing's volumetric method. The results of sugar are calculated in terms of the whole grape and not the

juice. The per cent of acid is calculated in terms of the juice as tartaric acid.

Number.	Name of Variety.	Total Sugar as Grape Sugar.	Acid.
450	Hartford	12.9 per cent.	1.20 per cent.
451	Ives Seedling	12.5 "	1.24 "
442	Lady	9.4 "	1.22 "
453	Herbert	11.5 "	Lost.
454	Moor's Early	12.6 "	1.00 "
455	Aminia	9.7 "	1.80 "
456	Delaware	15. "	1.20 "
457	*Catawba	8.8 "	2.00 "
458	Concord	14.4 "	1.82 "
459	Niagara	10.2 "	1.16 "
460	Lady Washington	14. "	1.74 "
461	Martha	14.2 "	1.52 "
462	Eumelan	13.8 "	1.57 "
463	Centennial	16. "	1.42 "
464	Brighton	16.6 "	Lost.
465	Northern Muscadine	11.4 "	1.25 "
466	Israella	15.4 "	1.60 "
467	Challenge	15.4 "	1.60 "

*Analyzed October 17, but not fully ripe.

NOTES ON VARIETIES OF GRAPES.

Especially desirable kinds are starred.

Agawam. Of strong growth, very hardy and moderately productive. Rather too late to warrant its planting for market.

Aminia.** An early, vigorous, productive black grape of excellent quality and fine appearance. In the experiment station vineyard it is very satisfactory.

Barry.* This variety has been very satisfactory with us Vine vigorous, hardy and productive; bunch large; berries very large and of good quality; skin thick; flesh sweet but somewhat pulpy.

Brighton.** Vigorous, hardy, healthy andproductive. Bunch very large; well shouldered; berry red; medium size; flesh very sweet; sprightly melting, superb; generally satisfactory. Not reliable enough for general marketing, but should be in every home garden. Its quality is rather improved, it ripens more evenly and keeps much longer if bagged;

when over ripe it loses much of its fine, sprightly quality. I know of no grape so much improved by bagging. Its blossoms are somewhat deficent in pollen and it should be planted near some kinds that have an abundance.

Catawba. Hardy and healthy enough and it sets a heavy crop of fruit, but seldom ripens. This season it was not fully ripe Oct. 17, although it was well colored at that date.

Centennial. A very productive white variety of moderate or poor growth. Bunches are of fair size and very compact. The berry is white, small and with very large seeds, of good quality. There are several more satisfactory white varieties. Ripens with concord.

*****Concord.** A little too late for general planting but in good vineyard locations in the south half of the state it is the most productive kind grown. Highly esteemed for general planting.

Cottage. A vigorous, healthy, productive black grape. Bunch large, shouldered; berry large, sweet and good; liable to drop from the stem.

****Delaware.** Geneally the most profitable grape to raise for market in this state, but it requires the best of care and the foliage should be sprayed with some fungicide to protect it from the downy mildew. Unless this is done it is extreme ly unreliable in wet seasons.

Duchess. A white grape of the best quality. Vine rather tender. Bunch, large, compact and shouldered; berry medium. Season later than Concord. Valuable in extra good locations.

Early Victor. One of the earliest kinds and of good quality. Bunches rather small; berry medium in size. Not sufficiently productive to make it profitable.

El Dorado. Of fine quality, but not sufficiently hardy nor productive enough to recommend it to any but amateur planters.

Elvira. A very vigorous and very productive white

grape of poor quality. It sometimes ripens here but is generally too late.

Eumelan. A good variety that, where healthy, is productive and desirable but its foliage is occasionally severely injured by mildew.

Green Mountain. A new grape that we fruited this year for the first time. The vine is vigorous, healthy, apparently hardy enough for our conditions, and I think very prolific. The bunches are of good size; the berry is pale green, medium in size, very sweet and melting, with thin skin. It ripens earlier than any variety of as good quality that we have. It drops from the bunch as soon as well ripened, which, with its green color, will prevent its being largely planted as a market variety. I think highly of it for the home garden in this state and recommend it for trial.

****Hartford.** Drops badly from bunch when over ripe. It It has been long and favonably known as a very vigorous, very hardy, very productive, early variety. Bunch large; berries black, large, sweet but pulpy and rather foxy. One of our best early purple kinds. It gives quite general satisfaction as an early grape for the home garden.

Herbert. Very vigorous, hardy, healthy, and productive. Bunch large; berry black, very large; skin thick; quality good. It would seem as if this variety shonld be more generally planted for market puposes.

Ives. Vigorous, healthy, hardy and productive. Bunch large; berries black and of medium size. This variety colors up very early, but like the Janesville it is not ripe until at least two weeks later. It is very firm and stands shipping well. As an early grape it is of such poor quality that it spoils the market for the better kinds, although it is often very profitable. When ripe there are many better varieties ripe. Except as a wine grape I consider it of little value.

***Janesville.** Very vigorous, healthy, hardy and productive. Bunch of medium size, very compact; berry of medium size, black, pulpy, acid. It colors up very early but

like the Ives it is not ripe until several weeks later. Pre-eminently the grape for severe locations and recommended for general planting in Minnesota.

*Lady. An early, greenish-white grape. Bunch medium compact; berry large and of excellent quality, but it sometimes cracks badly. Vine healthy and hardy but not a vigorous grower and only moderately productive. A valuable grape for amateurs.

Lady Washington. Vine healthy, hardy and vigorous. Bunch very large and rather loose: berry large, white and of fine quality. We ripened this variety in 1891 and 1892, but these were two exceptional years, Too late in ripening except in best locations.

**Lindley. Vine healthy, hardy vigorous and productive. Bunches medium in size and loose. Berries very large, red and of extra quality. This is an extra good keeping variety and holds its flavor well. It has frequently been exhibited in good condition at the winter meetings of the State Horticultural Society in January. Valuable for home use but must have pollen from other kinds to get good bunches.

Martha. Vine healthy, hardy and productive. Bunches of medium size; berries of medium size, greenish-white and of a very good quality. I think, however, that the Moor's Diamond or Pocklington are far better for home use or market.

Merrimac. Has done fairly well with us. The bunches are of good size; berries large and of extra quality. A good long keeping variety.

Moor's Diamond. A very distinct new white grape that is very promising. The vine is vigorous, healthy and productive. Bunches compact, shouldered, large; berries large: skin thick; flesh tender, juicy and melting. We have fruited it two years and consider it especially desirable for a standard white grape; Its season is from four to eight days earlier than the Concord.

*Moor's Early. One of the most popular early grapes.

Not generally a heavy cropper and some seasons the berries drop badly from the bunch as soon as ripe. Generally profitable on account of its being the first grape of good quality to come into the market. It requires rich soil and high cultivation for best results.

Moyer. Vine resembles the Delaware in foliage, growth and hardiness, but its bunch and berry are much smaller; berry sweet and melting. We fruited it this season for the first time. It ripens about a week before the Delaware and this quality will make it desirable if it proves to be sufficiently vigorous and productive.

Pocklington.** A most magnificent fruit. Vine healthy, hardy, vigorous and productive; berry white, very large and covered with beautiful bloom; quality sweet, juicy and extra good, though somewhat foxy. It ripens a little later than the Concord and is a worthy companion to that variety. Desirable only for good locations.

Salem. Quite satisfactory at the experiment station. Vines moderately productive, vigorous and hardy; bunches and berries large; skin thick and firm; flesh tender, juicy and sweet. A good shipping variety and a good keeper.

Wilder. This variety is too uncertain here and it is very liable to lose its leaves before the fruit is matured; with us much worse in this respect than the Delaware, which has never been seriously injured by mildew in the Station vineyard. This year it did not mature its fruit.

Worden.*** It is difficult to say too much in favor of this fine grape. The vine is vigorous healthy and productive; bunch large, compact, often shouldered; berries very large, black, with a heavy bloom; flesh sweet, melting and excellent. I think it is destined to replace the Concord for general planting in Minnesota on account of its being about ten days earlier, much superior to it in quality and nearly if not quite as prolific. Wherever known it commands a higher price than the Concord. Some seasons it seems more inclined to drop its berries than the Concord.

Woodruff Red. A new red grape. Vine vigorous, healthy and hardy; bunches small; berries large, bright red, with a beautiful bloom; flesh foxy, pulpy and sweet. We have fruited it but one season. I think it of too poor quality to pay for planting.

Wyoming Red. Vine vigorous, hardy and healthy but only moderately productive with us; bunches small to medium in size, compact; berries medium size, bright red; flesh sweet, pulpy, quite foxy, but it is very good for such an early variety. It is said to be growing in favor in the east as a very early red grape and is well worthy of trial by vineyardists here.

Varieties planted at the experiment station that have not yet fruited:

Eaton	Dracut Amber	Poughkeepsie Red
Herman Jaeger	Rommel	Peter Wylie
G. W. Campbell	Brilliant	Ebony
Atavite	Red Bird	Monitor
Solin Crup	Theophile	Marie Louise
Illinois City	Bertha	Dr. Warder
Emma	Witt	Nectar
Rockford	Mills	Triumph
Colerain	Early Ohio	Geneva

GRAPES.	Parentage	Quality for table use (scale 0-10)	Hardin's (scale 0-10)	Health of Foliage (scale 0-10)	Vigor of Growth (scale 0-10)	Productiveness (scale 0-10)	Size of Berry (scale 0-10)	Color of Berry	Keeping Quality [scale 0-10]	General Appearance [scale 0-10]	When Ripe in 1892...	REMARKS.
Agawam (Rog. 15	Lab. x Vin.	8	10	8	9	6	8	red	10	7	Oct. 3	Too late.
Aminia (Rog.39)**	Lab. x Vin.	8	8	8	9	7	7	black	7	8	Sept. 16	A reliable kind.
Bacchus	Riparia	1	10	8	10	8	4	black	6	8	Sept. 24	Good only for wine.
Barry (Rog. 43)*	Lab. x Vin.	8	7	8	6	8	8	black	8	8	Sept. 17	A valuable variety.
Brant	Riparia	4	8	8	9	8	3	black	3	4	Sept. 12	Rejected.
Brighton**	Lab. x Vin.	10	8	8	6	6	6	red	8	7	Sept. 25	Of finest quality.
Catawba	Lab. x Vin.	8	8	7	6	7	7	red	10	9	.....	Too late in ripening.
Centennial	Aestivalis	7	4	8	8	7	6	white	7	8	Oct. 4	Very productive.
Champion	.....	8	8	8	8	7	6	black	5	8	Sept. 14	Of poor quality.
Concord***	Lab.	7	6	9	10	10	7	black	8	8	Sept. 30	Well known.
Cottage	Lab.	9	9	9	10	6	7	black	7	7	Sept. 17	A valuable variety.
Clinton	Riparia	0	10	8	10	4	3	black	4	5	Oct. 1	Rejected.
Creveling	Lab. x	6	5	8	3	7	7	black	4	6	Sept. 13	Poor foliage.
Delaware**	Lab. x	10	7	8	4	4	3	red	8	10	Sept. 23	Well known.
Duchess	Lab. x	2	5	6	4	4	3	white	8	9	Oct. 3	Of very fine quality,
Early Victor	Lab.	2	0	7	8	5	5	black	4	7	Sept. 18	Not productive.
Elsinburg	Aest.	9	7	6	6	4	4	black	4	6	.....	Bunches very small.
Elvira	Lab. x	7	10	10	10	10	7	white	8	8	Oct. 7	Too late in ripening.
El Dorado	Lab. x	10	7	6	6	6	5	white	7	8	Sept. 20	Of fine quality.
Empire State	Lab. x Rip.	5	6	5	5	5	5	white	5	8	Oct. 5	Not productive enough.
Eumelan	Aest.	7	8	8	7	8	7	black	6	8	Sept 27	A good variety.
Faith	Rip. x	7	8	8	7	6	4	white	4	6	Sept. 15	Not valuable.
Goethe	Lab. x Vin.	?	9	7	7	?	9	?	?	?	.....	Too late in ripening.
Green Mountain	Lab.	9?	10	10	6	?	6	white	?	7	Sept. 29	A reliable new kind.
Hartford**	Lab.	6	9	10	10	8	7	black	5	7	Sept. 10	Very productive but drops badly.
F. B. Hays	Lab.	7	6	6	6	4	6	white	5	7	Sept. 17	Not sufficiently productive.
Herbert (Rog. 44.)	Lab. x Vin.	8	9	10	9	8	10	black	9	10	Sept. 20	Should be more widely known.
Ives	Lab.	3	10	10	9	8	7	black	5	7	Oct. 10	Very early but of poor quality.
Janesville*	Lab. x Rip.	4	10	10	10	7	7	black	7	8	Sept. 12	Very hardy.
Lady*	Lab.	9	8	8	7	4	6	white	7	7	Sept. 16	Rather weak grower.
Lady Washington	Lab.	8	8	8	8	7	7	white	8	9	Oct. 10	Too late in ripening.

GRAPES.	Parentage	Quality for table use (scale 0-10)	Hardin's (scale 0-10)	Health of Foliage (scale 0-10)	Vigor of Growth (scale 0-10)	Productiveness (scale 0-10)	Size of Berry (scale 0-10)	Color of Berry	Keeping Quality [scale 0-10]	General Appearance [scale 0-10]	When Ripe in 1892	REMARKS.
Lindley (Rog. 9)**	Lab. x Vin.	9	8	7	8	9	7	red	10	8	Sept. 27	Extra good keeper.
Massasoit (Rog. 3)	Lab. x Vin.	8	7	6	9	6	8	red	5	9	Sept. 27	Not productive enough.
Martha	Lab.	5	9	9	8	?	6	white	7	8	Sept. 30	There are better white grapes.
Merrimac (Rog. 19)	Lab. x Vin.	9	8	7	8	6	7	black	9	6	Oct. 1	Liable to mildew.
Montefiore	Lab. x Rip.	3	9	.....	6	6	5	black	.....	.....	Oct. 6	Not productive.
Moor's Diamond	Lab.	9	9	9	9	9	8	white	7	9	Sept. 28	A fine new white sort.
Moor's Early*	Lab.	9	8	9	9	6	9	black	5	9	Sept. 15	Generally not very productive.
Moyer	Lab. x.	9	8	9	8	5	7	red	6	7	Sept. 10	Bunches very small,
Niagara	Lab.	8	8	9	7	8	7	white	8	8	Oct. 4	Too late.
Northern Muscadine	Lab.	6	10	10	10	7	6	red	4	6	Sept. 15	Not prolific, drops badly.
Pocklington**	Lab.	9	9	9	9	5	9	white	8	9	Sept. 30	A magnificent variety.
Prentiss	Lab.	9	8	7	8	7	7	white	8	8	Sept. 30	Uncertain.
Salem (Rog. 53)	Lab. x Vin.	10	8	7	8	7	8	red	8	8	Sept. 30	A good variety.
Whitehall	Lab.	6	9	9	7	4	6	black	6	8	Sept. 15	Of very poor quality,
Worden***	Lab.	10	9	8	8	8	9	black	7	9	Sept. 20	Of best quality and early.
Woodruff Red.	Lab.	6	8	8	7	?	8	red	?	10	Oct. 2	Very handsome.
Wyoming Red	Lab.	6	9	8	8	7	7	red	7	9	Sept. 12	Very pulpy.
Wilder (Rog. 4)	Lab. x Vin.	9	8	6	8	8	8	black	7	9	?	Foliage liable to mildew.

*Especially desirable varieties are marked *, ** or ***, according to their value for general planting.

SMALL-FRUIT NOTES FROM OUR TRIAL STATIONS FOR 1892.

These stations were selected by the executive committee of the state Horticultural Society as proper places for testing new varieties that the Horticultural Division of the experiment station might desire to have widely tried.

FROM WINDOM, COTTONWOOD COUNTY.

DEWAIN COOK, SUPT.

Strawberries. A little over one-half a crop, but the Warfield was an exception. They gave a full crop of fine fruit. The Enhance is especially promising. The Sandoval I consider worthless on account of its liability to leaf fungus. The finest variety in this section was the Cumberland, grown on poor, sandy soil.

Raspberries. Most varieties of the suckering kinds were much troubled with some disease. The cap varieties were quite healthy. The Cuthbert did the poorest and Brandywine the best of all the reds, and all things considered I regard the last as the most reliable variety I grow. The black-caps Gregg and Souhegan are the best of their class.

Blackberries and Dewberries. Have done extra well and are in fine condition for a good crop next year. They stood the cold of last winter without protection. I am very much pleased with Ancient Briton, but do not consider it as hardy as Snyder, Agawam, Stone's Hardy or Wachusett.

Grapes. Have done finely in about every respect. Moor's Early, Delaware and Janesville have been the most satisfactory.

FROM LA CRESENT, HOUSTON COUNTY.

I. S. HARRIS, SUPT.

Strawberries were half to two-thirds a full crop. Warfield No. 2 when fertilized with Michel's Early did best of all. Kramer's Princess came next to Warfield and Crescent came in for third place.

Parker Earle promised the best of all but for some reason all but the first picking was small and poor.

Michel's Early did not prove satisfactory as a fruiter.

Captain Jack did not bring half a crop.

Jessie was nearly a total failure.

The varieties in our new experiment plantation were set late in 1891 and did not make a very satisfactory growth. Of the new varieties the most promising among them were the Haverland, Schuster's Gem, Eureka, Pearl, Bubach and Crawford. The Warfield and Crescent hold the lead for commercial purposes, but a better pollenizer than we now have is needed for them.

Raspberries were about half a crop. The Ohio black cap is the best of the cap varieties, and the Cuthbert and Marlboro the best of the red. Turner continued longest in bearing but the yield was light. None of the reds were entirely exempt from "curl leaf."

Blackberries have done the best of all the small fruits. The crop was immense and the quality good. The Ancient Briton is taking the lead as a market fruit.

Grapes were considerable below an average crop. Mildew was very abundant and destructive.

Delaware, Niagara, Lady, Pocklington and some of the Roger's hybrids lost much of their foliage from mildew and consequently failed to ripen.

Moor's Early set but little fruit.

Concord, Worden and **Brighton** are doing the best with me.

FROM FERGUS FALLS, OTTER TAIL COUNTY.

F. H. FIELDER, SUPT.

STRAWBERRIES.

Bubach. (p) The largest berry I grow; very vigorous and one of the best for this section.

Cloud. (p) Did not fruit much.

Daisy. (p) Not as good as Crescent, nor so large.

Jessie. (b) A fine berry, and did the best of all this season.

Oliver. (b) Did not produce fruit.

Warfield. (p) More productive than Crescent; makes the largest amount of runners I ever saw.

Wilson. (b) Too small.

Crescent. (p) As good as many varieties, but I think the Bubach and Warfield are better.

RASPBERRIES.

Turner. Too small this season.

Caroline. Berries soft and of poor quality, but very productive.

Cuthbert. Best of the Raspberries.

Gladstone. Of no value. Berries small, dull red.

Gregg. The best blackcap I grow.

Dewberry. Quite productive, but berries are small, imperfect and of poor quality,

FROM ALBERT LEA.

CLARENCE WEDGE, SUPT.

STRAWBERRIES.

Michel's Early ripened a few berries the first of any variety, but was a light crop and is worthless except as a pollenizer.

Crescent produced at least three times as many berries per row as any other variety grown, and throughout the wet hot weather remained in choice condition for home market.

Wilson came next to Crescent in yield of fruit, but its color and the dead condition of the Calyx gave them a poor appearance.

Jessie and **Bubach** were the special delight of a big flock of birds, which prevented my getting any perfect fruit from them. Neither of these varieties would have given a profitable crop, however, even if the birds had let them alone. The Bubach rotted before it was ripe enough to pick. A few plants of Haverland fruited and gave promise of something fancy for the home market and I shall plant them largely next year.

RASPERRIES AND BLACKBERRIES.

The Cuthbert raspberry is the most satisfactory variety I have. I grow Ancient Briton, Snyder, and Wilcox blackberries and the Ancient Briton is the best of all.

FROM MINNSOTA CITY.

O. M. LORD, SUPT.

Strawberries. A fair crop. Warfield No. 2 exceeded all others in yield. Crescent came next; then Bubach, Jessie, Princess and Downer's Prolific in the order named. The last rusted so much as to materially reduce the yield.

Raspberries. The Gregg did very well and the Schaffer was abundant.

Blackberries. Ancient Briton, Snyder and Stone's Hardy all did well.

University of Minnesota.

Agricultural Experiment Station.

BULLETIN No. 26.

CHEMICAL DIVISION.

JANUARY, 1893.

DIGESTION EXPERIMENTS.

MILCH COWS.

I. PEA ENSILAGE AND WHEAT BRAN.

PIGS.

II. BARLEY AND SHORTS. III. BARLEY. IV. CORN AND SHORTS. V. CORN. VI. SHORTS. VII. CORN AND BRAN. VIII. PEAS AND BRAN. IX. PEAS. X. BRAN.

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Digestion Experiments.

BY HARRY SNYDER.

OBJECT OF THE BULLETIN AND EXPLANATION OF TERMS.

This bulletin contains the results of experiments upon the digestibility and manurial value of pea ensilage and wheat bran when fed to milch cows. The results show what becomes of each ingredient of the food, the amounts of each recovered in the milk, returned in the dung and urine and the amount required as fuel to carry on the vital functions. These experiments are given in detail so as to serve as an outline for the remainnig experiments upon the composition and digestibility of barley and shorts, barley, corn and shorts and corn, fed to grown pigs; and corn and bran, peas and bran and peas, when fed to growing pigs.

The determination of the digestibility of a fodder is simply finding the amount of it that can be utilized by the animal. A fodder, as clover, is said to be sixty per cent digestible; this means that out of every hundred pounds of the dry clover hay, sixty pounds are broken down in the digestive tract, and forty pounds are not acted upon, but leave the body undigested in the dung. Each constituent of every fodder has its own digestibility.

A digestion experiment is carried on in the following way: An animal, as a cow, sheep or pig is fed for some time upon the particular food in question, the food being carefully weighed and analyzed. This is carried on at first simply for a preliminary feeding period, the object of which is to get the animal in the same condition as it will be later on when the experiment is in progress. After this preliminary feeding all

of the dung is collected as evacuated, weighed and analyzed. This is done for a number of days. The dung and urine made for any number of days are the products of the food for an equal period. In the dung a certain portion of each of the components of the food is returned undigested; this is determined, and this amount not digested, when taken from the amount of that ingredient in the original food gives the amount digested. The results are usually expressed in percentages, and the per cent digested is called the digestion coefficient.

The names of the different fodder constituents, and the terms used in this bulletin may not be familiar to some readers, and are here briefly explained.

All food stuffs are composed of water and dry matter;the water is sensibly present in the juices, and even in field cured hay or fodder corn there is always more or less water. The larger part of the dry matter when burned is converted into smoke, while a small portion remains as ashes. The part that is burned is called the organic part.

The first general division of the constituents of fodders and food stuffs, then, is into water and dry matter; and the second, the dry matter into ash and organic matter- A farther division of the organic part is made into those compounds that contain an element or building unit known as nitrogen, and those that do not contain this element. The compounds that contain nitrogen are called nitrogenous compounds, while those that contain no nitrogen are called non-nitrogenous. All fodders contain from four to ten times more of the non-nitrogenous compounds than of the nitrogenous ones.

The most important among the nitrogenous compounds is crude protein, which includes a large class that have certain characteristics in common, one of them being that they all contain about the same per cent—16%—of the element nitrogen. The white of an egg is a typical example; lean meat is composed largely of these kinds of substances. The protein compounds of food stuffs are extremely valuable as animal food inasmuch as they contain the building materials that compose the muscles. Crude protein is usually

spoken of as muscle or flesh forming material. The protein compounds are more familiarly known as the crude albuminoids; in this work, however, both terms are used, each one having a separate meaning. Some authorities* restrict the term albuminoids to such bodies as gelatine, while others use proteids and albuminoids as synonymous terms. All albuminoids are proteids, while not all of the so called proteids, as usually determined, are albuminoids. In the analysis of plants and food stuffs the total nitrogen that is found is taken as the basis for determining the crude protein. All of the nitrogen thus determined is not in the form of albuminoids, and can not be taken as a basis for determining the albuminoids. These are determined from the albuminoid nitrogen alone. Hence the distinction is made between the total nitrogen and the nitrogen that belongs only to the albuminoids. In the columns headed "Crude Protein" the total nitrogen is taken as the basis for its determination, while in the column headed "Albuminoids" the albuminoid nitrogen is taken as the basis.

Ether Extract is the material which is extracted from fodders by ether, and is composed largely of fat, with variable quantities of foreign substances such as wax and coloring matter. In fodder analyses this is sometimes called fat or oil, but it is not pure fat.

Crude Fiber is the woody part of plants; it belongs to the same group of chemical substances as starch and sugar. In young and tender plants the fiber is more digestible than when the plant becomes tough and woody.

Nitrogen Free Extract is the name given to the remaining compounds that contain no nitrogen—free from nitrogen—and are soluble in weak acid and alkaline solutions. Such are the jellies, sugars and starches.

The ether extract, the crude fiber, and the nitrogen free extract, when digested supply the body with heat and produce fat, while the main functions of the protein compounds is to supply the materials for the muscles and waste matter. Hence the two general classes of compounds in food are the

*Johnson.

nitrogenous or flesh forming, and the non-nitrogenous or heat and fat producing bodies.

These different classes of compounds, found in food stuffs, are not equally digestible, the fibrous or woody part usually being less digestible than the starches or sugars. Each separate compound of a fodder has its own digestibility or digestion coefficient, which it is the object of a digestion experiment to determine.

Many digestion experiments have been made with nearly all the different animal foods, and the results obtained have been of material value. The importance of this work was clearly foreseen by the framers of the Hatch bill, establishing experimental stations, who in particular mentioned digestion experiments as one of the important lines of work to be conducted by them.

I. PEA ENSILAGE.

Digestibility and Value as a Cattle Food.

The few digestion experiments that have heretofore been made with peas and pea meal, show that pea meal is one of the most digestible and valuable of animal foods; but little, however, seems to have been done in the way of determining the digestibility and value of the whole plant either field cured, or ensilaged, as cattle food. The following experiment was carried out in order to obtain some data in regard to this question, particularly when the ensilage is fed to milch cows.*

The peas were cut while green and put into a separate compartment of an experimental silo, which was opened early in March, 1892. When opened, the ensilage was sweet and in good condition, and an analysis of it showed that it had the following composition:

		Composition in Pounds Per Hundred of Dry Matter.				
Water.	Dry Matter	Ash.	Ether Extract.	Crude Protein.	Crude Fibre.	Nitro. Free Extract.
50.08	49.92	6.95	3.13	11.90	26.00	52.02

The points to be observed from this analysis are: That the material contains a comparatively large percentage of nitrogenous compounds, more ash and less water than ordinary ensilaged cattle foods; these are points that are all in its favor.

At the time this silo was opened the cows were receiving a corn ensilage and mixed grain ration; and some of the cows when gradually changed to pea ensilage and less grain did not seem to relish it as well as the usual corn ensilage,

*For the manner of growing peas, and their yield, the reader is referred to Bulletin No. 20, of this Station.

while others ate it equally as well. With different cows there was a difference as to the apparent palatability of the pea ensilage. Many cows that refused to eat the pure ensilage alone were induced to eat liberal quantities of it by mixing bran, timothy, or corn with it. The feeding was not carried on with a sufficient number of milch cows or for a period of sufficient length to warrant any definite conclusions as to the effects upon the yield or composition of the milk; however, the daily dairy record of the herd shows no appreciable variations either in the total yield of milk or fat while the pea ensilage was being fed. This ration of pea ensilage and bran, however, took the place of one of corn ensilage, hay, and a mixed grain ration consisting of 5 lbs. barley, 3 lbs. bran and 1 lb. oil meal per day, with a saving of the more expensive barley meal and oil meal.

The two cows selected for this experiment were Sully and Bess. Both cows were of about the same age, and had been in milk for about five months. The daily ration consisted of a mixture of thirty-four pounds of pea ensilage and twelve pounds of wheat bran. The food was restricted to these two articles so as not to introduce other factors in the experiment. The preliminary feeding lasted fourteen days. During this time the cows were gradually accustomed to the confinement and the constant presence of an attendant. Beginning at noon on March 25th and ending at noon on March 30, the solid and liquid excrements were caught as evacuated, by an attendant constantly in charge both day and night. This constant attendance prevented losses and removed many of the sources of error, such as the mixing of the dung and urine and the use of absorbents for collecting them. All of the food fed to each cow was eaten, leaving no factor for food rejected, or leavings. A daily record was kept of the weight of each cow and also the water consumed. The manure of each cow was mixed and sampled in duplicate at three different times during the experiment. The analyses of the food consumed, the manure at the different times of sampling, the milk yielded, and the urine voided, are given in tabular form on the following pages.

A sample of the pea ensilage was taken at every removal

of the ensilage from the silo, and the average of the results show the composition of the pea ensilage fed:

		(Pounds per hundred of the dry matter.)					
Water.	Dry Matter.	Crude Protein.	Ash.	Ether Extract.	Fiber.	Nito. Free Extract.	True Albuminoids.
52.88	47.12	11.90	6.50	3.00	25.00	53.60	10.50

Comparing the results of the analysis when the silo was opened, with the average results of the ensilage fed, it will be observed that the ensilage was quite uniform in composition, the water being the most variable constituent.

The wheat bran fed with the pea ensilage had the following composition, the results being expressed in pounds per hundred of the dry matter:

Dry Matter.	Ash.	Crude Protein.	Ether Extract.	Crude Fiber.	Nitro Free Extract.	True Albuminoids.
90.00	4.20	13.20	3.1	6.00	73.50	12.00

During the five days that the dung and urine were collected, 170 pounds of ensilage and 60 pounds of wheat bran were fed to each cow; and the number of pounds of each nutrient fed in both the pea ensilage and wheat bran, and the totals, are given in the following table:

POUNDS OF FOOD COMPOUNDS CONSUMED.

Kind of Food.	Water Pounds	Dry Matter Pounds	Ash Pounds	Crude Protein Pounds	Ether Extract Pounds	Crude Fiber Pounds	Nitrogen Free Extract Pounds	True Albuminoids Pounds
In 170 lbs. Pea Ensilage	89.9	80.1	5.206	9.53	2.40	20.04	42.94	8.41
In 60 lbs. Wheat Bran...	6.0	54.0	2.27	7.18	1.67	3.22	39.69	6.48
In 230 lbs. Totals.....	95.9	134.1	7.47	16.71	4.07	23.26	82.63	14.89

The total nitrogen present in the dung is but partly in the form of undigested protein compounds; the bile contains compounds, such as glycocholic acid, which contains nitrogen and are digested products. In the crude protein column a correction is made for these small amounts of digested nitrogenous compounds. In the tables, the samples A and B are duplicate samples of the manure for the same period, and the results that are given for each sample are the averages of duplicate analyses, making in all a total of twelve analyses of the manure of each cow.

BESS.—SOLID EXCREMENTS.

Description of Samples.						Composition of Dry Manure per Hundred Pounds.								
Period	Time in hours	Total pounds of Manure	Samples	Water per Cent	Dry Matter per Cent	Ash	Crude Protein	Ether Extract	Nitrogen Free Extract	Crude Fiber	Total Nitrogen	Albuminoid Nitrogen	True Albuminoids	Totals
First...	36	55.	A B	84.50 84.30	15.50 15.70	9.03 9.21	11.40 11.52	2.06 2.04	46.10 46.01	31.41 31.22	1.82 1.84	1.37 1.34	8.56 9.00	100
Second	36	61.5	A B	84.85 85.41	15.12 14.59	8.90 9.00	10.44 10.37	2.54 2.70	47.00 47.17	30.52 30.76	1.67 1.66	1.36 1.31	8.50 8 18	100
Third..	48	89.25	A B	84.23 85.03	15.87 14.97	8.90 9.08	10.06 9.62	2.85 3.00	46.64 46.74	31.65 31.56	1.61 1.54	1.31 1.30	8.10 8.12	100

POUNDS OF EACH CONSTITUENT IN THE MANURE.

First...	36	55	0 Average. 0	46.50	8.50	.785	.893	.175	3.951	2.68	.157	.116	.753	8.50
Second	36	61.5		52.35	9.15	.818	.952	.239	4.307	2.80	.152	.121	.762	9.12
Third..	48	89.25		75.08	14.16	1.274	1.394	.413	6.61	4.41	.224	.184	1.15	14.16
Totals	5 days	205.75		173.93	31.81	2.877	3.239	.829	14.87	9.95	.534	.422	2.666	31.78

SULLY.—SOLID EXCREMENTS.

Description of Samples.						Composition of Dry Manure per Hundred Pounds.								
Period	Time in Hours	Total Pounds Manure	Samples	Water per Cent	Dry Matter per Cent	Ash	Crude Protein	Ether Extract	Nitrogen Free Extract	Crude Fiber	Total Nitrogen	Albuminal Nitrogen	True Albuminoids	Total
First...	36	58.5	A	84.00	16.00	9.51	11.13	2.43	46.81	30.12	1.78	1.31	8.18	
			B	84.12	15.88	9.33	10.85	2.66	46.96	30.20	1.72	1.37	8.56	100
Second	36	59.25	A	84.81	15.19	8.40	10.31	2.90	50.26	28.13	1.63	1.29	8.06	
			B	84.25	15.75	8.55	10.19	3.15	50.11	28.00	1.65	1.33	8.31	100
Third	48	84.25	A	84.85	15.15	8.42	9.88	2.44	45.71	34.55	1.58	1.26	7.93	
			B	85.89	14.11	8.59	10.26	2.12	45.62	33.41	1.63	1.30	8.18	100

POUNDS OF EACH CONSTITUENT IN THE MANURE.

First...	36	58.5	0 Average 0	49.18	9.32	.864	.985	.237	4.39	2.82	.163	.125	.781	9.31
Second	36	59.25		50.08	9.17	.778	.940	.278	4.60	2.57	.154	.120	.752	9.17
Third..	48	84.25		71.95	12.30	1.05	1.248	.280	5.60	4.15	.197	.158	.996	12.32
Totals	5 days	202		171.25	30.79	2.692	3.173	.795	14.59	9.54	.514	.402	2.529	30.80

From these tables it will be observed that the manure from each cow was quite constant in composition and quantity, the water again being the most variable constituent. The average number of pounds of manure made by Sully per day being 40.5, by Bess 41.2. Taking the yield and the composition of the manure as an index to the condition of the digestive tract, it appears that all of the functions were carried on with uniformity, since both the yield and the composition of the manure were constant.

SUMMARY OF RESULTS.

Kind of Sample	Dry Matter	Ash	Organic Matter	Crude Protein	Ether Extract	Crude Fiber	Nitrogen Free Extract
BESS.							
Total pounds in food	134.1	7.47	126.6	16.71	4.07	23.26	82.63
Total pounds in manure	31.81	2.88	28.93	3.24	.83	9.95	14.87
Pounds digested	102.29	4.59	97.66	13.47	3.24	13.31	67.76
Co-efficient of digestibility	75.5	61.4	77.	80.6	79.6	56.9	82.
SULLY.							
Total pounds in food	134.1	7.47	126.6	16.71	4.07	23.26	82.63
Total pounds in manure	30.79	2.69	28.1	3.17	.80	9.54	14.59
Pounds digested	103.31	4.78	98.5	13.54	3.27	13.72	68.04
Co-efficient of digestibility	76.9	63.9	77.8	81.2	80.3	58.9	82.3

Two determinations of the digestibility of wheat bran will be found in another article in this bulletin; in one case wheat bran is found to be *more* digestible and in another *less* digestible than the mixed pea ensilage and bran. From these facts it appears that the pea ensilage alone must be at least as digestible as the bran. The effect of one food upon the digestibility of another is not well known; shorts and bran are both more digestible in one grain ration than in another. The bran fed in these experiments contained less fiber and ash than ordinary bran, and in this respect resembled more the composition of shorts. This would tend to increase the digestibility of the bran. The digestibility of the bran can not be assumed, and the pea ensilage digestibility determined by difference, inasmuch as there are two un-

known factors that tend to increase the digestibility of the pea ensilage, viz: A different composition from ordinary bran, and combination with a more digestible food.

Whatever these unknown factors may be the results show that the pea ensilage alone can not be less digestible than the results given for the peas and bran, and making due allowance for these two factors, the digestibility of the pea ensilage is, no doubt, not far from the figures assigned to the mixture.

The results farther show that when pea ensilage is introduced into the feed of milch cows, it forms the basis of a very digestible ration.

Comparing the digestion work of these two cows, it will be observed that there is a marked uniformity. About one per cent more of the total organic matter was digested by Sully than by Bess. With Sully there was a slightly greater tendency toward the more complete digestion of the nitrogenous compounds.

Milk Yield.—Complete analyses were made of the milk from each milking. In the five days Sully gave 98.5 pounds of milk, and Bess gave 108.7. The total number of pounds of fat, ash, sugar, casein, and solids, in the milk of each cow for the five days were:

	Total pounds of milk	Water	Solids	Ash	Fat	Casein	Sugar
Sully..	98.5	85.3	13.2	7.51	4.557	3.83	4.06
Bess...	108.7	97.2	11.5	.62	3.667	3.30	3.91

From the same number of pounds of food Bess gave ten pounds more milk than Sully; but the 108 pounds of milk from Bess contained less fat and solids than the 98.5 pounds given by Sully. Sully's milk, although ten pounds less, produced .89 pounds more of fat, which if made into butter would make a difference of over one pound in five days. Each cow consumed 134.1 pounds of dry matter in the food to produce 13.2 and 11.5 pounds respectively of solid matter in the milk.

In the case of Bess 8.58 per cent of the solid matter of the

food was returned in the solid matter of the milk, while with Sully 9.85 per cent was returned. The difference in the weight of the solid matters digested by the two cows, 1.02 pounds, does not entirely account for the difference in the solid matter of the milk produced, 1.7 pounds. This question will be farther discussed after considering the amount of the nitrogen of the food retained in the body of each cow, and the gain and loss in live weight.

The composition and quantity of the urine is another important factor in determining the completeness of the digestive process, inasmuch as over half of the nitrogen of the food, in these experiments, was returned in the urine.

AVERAGE COMPOSITION OF A HUNDRED POUNDS OF URINE.

	Total Lbs.	Water.	Solids.	Ash.	TotalNitro.
Bess	115	91.76	8.24	3.00	1.21
Sully	110.5	91.3	8.70	3.15	1.24

TOTAL POUNDS IN THE URINE OF EACH COW.

Bess	115	105.55	9.54	3.45	1.39
Sully	110.5	100.82	9.63	3.45	1.35

All of the data concerning the total dry matter, ash and total nitrogen of the food, and the amount of each recovered in the dung, urine and milk will be found tabulated below:

BESS.	Dry Matter.		Ash.		Nitrogen.	
	Pounds	Per Cent	Pounds	Per Cent	Pounds	Per Cent
In food	134.1	.....	7.47	.....	2.66	.....
In dung	318.1	23.7	2.88	38.5	.53	20.
In milk	115.	8.50	.62	8.00	.51	19.1
In urine	94.5	7.04	3.56	47.	1.39	52.25
Totals Returned	52.76	39.4	6.95	93.	2.43	91.3

SULLY.	Dry Matter.		Ash.		Nitrogen.	
	Pounds	Per Cent	Pounds	Per Cent	Pounds	Per Cent
In food	134.1	.....	7.47	.....	2.66	.....
In dung	30.79	23	2.69	36.	.52	19.5
In milk	13.2	9.85	.77	1.	.65	24.4
In urine	9.63	7.18	3.45	46.	1.35	50.7
Totals Returned	53.62	40.	6.90	92.3	2.52	94.7

Bess returned 39.4 per cent of the total dry matter of the food; Sully returned 40 per cent in the dung the milk and the urine. The question naturally arises, What becomes of the remaining 60 per cent of the total dry matter of the food, since it is not returned in the dung, urine or milk? It must be remembered that there is another means of escape of the food that has not as yet been considered, namely: the losses by respiration and through the pores of the skin. The food during digestion undergoes a series of chemical changes, the body is supplied with heat, and this heat is the result of the burning of some of the food. When food is burned either within the body or outside it is reduced to gaseous products and is no longer solid matter.

The per cent of nitrogen returned by each cow was somewhat less than the amount in the food. Sully returned nearly 95 per cent, while Bess returned a little over 91 per cent, indicating that none of the vital functions had been carried on at the expense of the muscles of the body without due compensation from the protein of the food. Nearly the same per cent of ash was returned by each cow.

Had the pea ensilage been less digestible, a larger daily quantity of food would have been required to furnish these amounts of digestible compounds, and more undigestible nitrogen would have been returned in the dung.

In this case the percentage of nitrogen returned in the dung would have been correspondingly greater. Hence the per cent of the nitrogen of the food, returned in the dung, urine and milk for one food does not, and cannot be applied to another food, since the foods may have both a different chemical composition and different co-efficients of digestibility.

The gain and loss in weight of the cows was within narrow limits, and was materially influenced by the amount of water consumed; the variations in live weights cannot be taken alone as actual indications of gain or loss in flesh, due to the pea ensilage and wheat bran, because the variations in live weight are small compared with the daily amounts of water consumed, which in turn are unequal for the two cows. The amount of water given off by the lungs and also

the amount formed by the combustion of the food are unknown factors, and no accurate estimates of these amounts can be formed. About eighty-two pounds of dry matter were burned up in the body of each cow, equivalent to a little over sixteen pounds per day.

The total weight of the two cows at the close of the experiment was seventeen pounds less than at the beginning. Bess gained ten pounds and Sully lost twenty-seven. Bess consumed twenty-eight pounds more water than Sully, and also returned sixteen pounds more in the dung, urine and milk, as the following table will show:

WATER CONSUMED.

	BESS. Pounds.	SULLY. Pounds.
In drink	308	280
In food	96	96
Total.	404	376

WATER RETURNED.

	BESS. Pounds.	SULLY. Pounds.
In urine	105.5	100.8
In milk	92.7	84.3
In dung	174.	171.
Total	372.	356.
Not returned	32.	20.

The amount of water in the dung, urine and milk of Bess amounted to 372 pounds, thirty-two pounds less than the amount that she consumed, equivalent to six pounds per day in addition to that formed by the combustion of the food to be disposed of by the lungs and pores of the skin. With Sully twenty pounds more of water was consumed than returned. Bess returned sixteen pounds more water than Sully, or a difference of twelve pounds more than the difference between the amounts consumed and returned by Sully. Hence the loss of weight of Sully is not a loss in flesh. This is shown more conclusively in the nitrogen return of the food already referred to.

From the same number of pounds of food, Bess gained ten

pounds on live weight and retained nearly three per cent. more nitrogen in her body than Sully. Sully made no gain in live weight, digested one per cent more of solid matter of the food and returned over one per cent more solid matter in the milk, which made a return of over one pound of butter in five days. Taking these facts into consideration it is plain to be seen why Sully made a better milk rerurn than Bess when each consumed the same number of pounds of food.

The more complete digestive work of Sully; with no tendency to gain in flesh or retain the nitrogen of the food, gave better milk returns than the less complete digestive work of Bess with a tendency to gain in weight and to retain more of the nitrogen of the food.

In feeding, any one of these factors taken alone would usually be considered too small to be of any account, and within the limits of error; but these are the factors when working together that go far towards making dairying successful or unsuccessful, since they are the results of the mechanical workings of a good dairy cow compared with a poorer one that consumed the same quantity of food, but produced one-fifth of a pound less of butter per day.

THE MANURIAL VALUE OF PEA ENSILAGE.

Another important factor in considering the value of any cattle food is the composition and value of the manure returned. The elements, the compounds of which give a manure its commercial value are nitrogen, phosphoric acid and potash, since these are usually the important materials that are found in the least abundance in the soil. In commercial fertilizers, nitrogen in its most available forms is valued at 17 cents per pound, phosphoric acid at about seven cents and potash at about four cents. Farm manures contain these same elements in forms equally as valuable, and an analysis of the dung and urine of any animal, fed on any

food, shows the number of pounds of these compounds contained in a hundred pounds of the manure. Multipiying the pounds per hundred of nitrogen, phosphoric acid and potash by twenty will give the number of pounds of each per ton. The price of each element per pound being known the value per ton can then easily be determined. An analysis of the dung and urine of each cow showed the average percentages, or pounds per hundred, of nitrogen, phosphoric acid and potash to be:

	Nitrogen.	Phosphoric Acid.	Potash.
Dung	.26	.44	.32
Urine	1.21	.06	1.09

	DUNG.			URINE.	
	Lbs. per Ton.	Value.		Lbs. per Ton.	Value.
Nitrogen	5.2	$ .884	Nitrogen	24.1	$3.497
Phos. Acid	8.8	.616	Phos. Acid	.12	.084
Potash	6.4	.254	Potash	21.8	.872
Value per ton		$1.754	Val. per t'n		$4.453
Value per day of dung		$036	Value per day of urine		$ .049

Value per day of mixed dung and urine, ... $.085
" " ton " " " " 2.70

This is much higher than manure is usually rated by farmers of the state, and in many cases is more than it would be worth to them; however, it represents what these same elements would cost if purchased in the form of commercial fertilizers. From these figures it will be seen that the nitrogen is by far the most expensive element in the manure. Of the total nitrogen in the food, about twenty per cent was returned in the dung, from twenty to twenty-five per cent in the milk, and over fifty per cent in the urine. Nearly all of the phosphoric acid was returned in the dung.

The results show that the urine is of greater commercial value than the dung, since half of the nitrogen of the food was returned in the urine, and only a fifth in the dung. The nitrogen in the urine is soluble and more available as plant food, while the nitrogen in the dung is largely insoluble, as the determinations of albuminoid nitrogen show. The value of the manure depends mainly upon the nitrogen, and this is contained largely in the urine.

Care should be taken to lose as little of the urine as possible. This can be done by closing up the leaks in the stable floor, maintaining well constructed gutters, and the liberal use of straw and other absorbents.

In conclusion, the important points briefly stated in regard to ensilaged peas and wheat bran as a cattle food, are;

1. Peas furnish a food rich in nitrogenous compounds, of which the dry matter contains about twelve per cent, which is about twice the amount in ordinary ensilaged crops.

2. In every hundred pounds of the dry matter, seventy-six pounds were digested, and all of the constituents, except the ash and fiber, were nearly equally and evenly digestible.

3. The pea ensilage and bran alone took the place of corn ensilage, hay and a mixed grain ration, saving the more expensive barley and oil meal, and giving the same milk and butter yield.

4. The cow that gave the better returns in milk and butter from the same weight of food digested one per cent more of solid matter and retained three per cent less nitrogen than the one that gave a fifth of a pound less butter per day.

5. Nearly ninety-five per cent of the nitrogen of the food was returned in some form; about one-half was returned in the urine, one-fifth in the dung, and from one-fifth to one-fourth in the milk.

6. About eighty- two per cent of the original fertilizer materials in the food was returned in the dung and urine.

7. Finally, pea ensilage is a valuable cattle food, rich in nitrogen, largely digestible, and returns a valuable manure to the soil.

The storing of peas in the silo as described in this article may be unfamiliar to many and appear to be out of the reach of the ordinary farmer, but this is not so. A silo like the one in which these peas were stored can be made by any farmer at no great expense, and anyone who is desirous of securing one more valuable cattle food, should give peas, either field cured or ensilaged, a trial.

II. BARLEY AND SHORTS.

Digestibility and Manurial Value.

For this experiment a Poland-China-Duroc-Jersey barrow weighing about 250 pounds was used. The experiment was carried on in May at medium temperature. The pig was of a quiet disposition, and did not seem to be disturbed by the close confinement. The daily ration fed consisted of 9 5-7 pounds of a mixture of one-half barley and one-half shorts by weight. The percentage composition of each was.

	Water	Dry Matter	Ash	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Ex.
Barley.....	11.78	88.22	2.32	2.70	11.57	6.00	65.63
Shorts.....	10.12	89.88	2.79	4.90	13.75	8.35	60.09

After the preliminary feeding the dung and urine were collected; the pounds of ash, fiber and protein, in the thirty-four pounds of each of the feeds consumed, and the totals, are given in the following table.

	Water	Dry Matter	Ash	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Ex.
Barley.....	4.005	30.00	.789	.918	3.935	2.04	22.24
Shorts.....	3.443	30.55	.949	1.666	4.675	2.84	20.43
Total.....	7.448	60.55	1.738	2.584	8.610	4.88	42.67

The experiment was divided into two periods of three and four days each. During the first period nearly 25 pounds of manure was made, or an average of eight pounds per day, which contained 1.91 pounds of dry matter; during the second period 31 pounds were made or an average of about eight pounds per day, which contained about two pounds of dry matter.

AVERAGE COMPOSITION OF DRY MANURE IN POUNDS PER 100.

Period..	Water	Dry Matter	Ash	Ether Extract	Crude Protein	Nitrogen Free Ex.	Crude Fiber	True Album'ids
First....	77.36	22.64	14.54	3.80	16.22	42.72	22.62	12.50
Second.	74.50	25.50	10.22	4.82	14.72	45.62	24.52	11.88

The variations in the composition of the manure for the two periods are greater than in the experiment with pea ensilage and wheat bran. The differences in composition of the manure for the two periods when calculated to the number of pounds of fiber, protein, etc., made per day, are partly balanced by differences in dry matter, and the total weight of the manure for each period. All of the important data of this experiment will be found in the following table:

SUMMARY OF DIGESTION RESULTS.

	Dry Matter	Ash	Organic Matter	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Extract	True Albuminoids
Total pounds in food.....	60.55	1.738	58.812	2.584	8.61	4.88	42.67	7.65
Total pounds in manure	13.56	1.632	11.822	.596	1.92	3.22	6.01	17.45
Total pounds digested...	46.99	.106	46.984	.199	6 69	1.66	36.66	5.90
Co-efficient of digestibility of shorts and barley	77.61	.600	7.970	7.895	7.77	34 01	85.92	77.12

The co-efficient of digestibility for the crude protein, if not corrected for the biliary nitrogen would be 75.8, showing that the biliary matters, as ordinarily determined, affected the results to the extent of about two per cent.

Twenty-eight pounds of urine was made during the seven days. The average composition showed that the urine contained 5.60 per cent solids, .38 per cent ash and 2.05 per cent nitrogen. In the 28 pounds of the urine there were about 26.2 pounds of water, .11 pounds of ash, and .57 pounds of nitrogen.

The pounds of nitrogen and ash in the food and the pounds recovered in the dung and urine were:

	ASH.	NITROGEN.
In food	1.739	1.37
In the dung	1.63	.32
In the urine	.11	.57

The sum of the ash and nitrogen in the dung and urine, when taken from the number of pounds in the food leaves the amount retained in the body which is .48 of a pound for the nitrogen, and no appreciable amount for the ash. During the same period the pig consumed 111 pounds of water, of which 69 pounds passed in the dung and urine and 42 pounds were either in part retained in the body or given off through the pores of the skin and by respiration. At the beginning of the experiment the pig weighed 254 pounds, and at the close 273 pouuds, the daily weighings showing an average gain of over 2 pounds. A large proportion of this gain was a gain in flesh, since over 65 per cent of the nitrogen of the food was retained in the body.

An average of eight pounds of manure and four pounds of urine were made per day; a fertilizer analysis of the fresh mannre and the urine showed the following percentage composition:

	MANURE.	URINE
Nitrogeu	.57%	2.05%
Phosphoric Acid	.72"	.06"
Potash	.32"	.04"

If these constituents of the dung and urine were purchased in eastern markets in the form of commercial fertilizers, based upon analysis, the dung would be valued at $3.30 per ton and the urine $7.31 per ton. The value of the dung made in one day would be worth $.012 and of the urine $.016. The mixed urine and dung together would be worth nearly three cents per day. The analysis shows that the urine is of greater money value than the dung, since over 40 per cent of the nitrogen of the food was returned in the urine, while about 25 per cent was returned in the dung.

III. BARLEY.

Digestibility and Manurial Value.

After determining the digestibility of barley and shorts, this same pig was gradually changed from barley and shorts to a ration of pure barley, and the digestibility of the barley separately determined. In this experiment the dung and urine were collected for six days; during this time, as well as during the preliminary feeding period, 6 pounds of barley was fed per day. The barley was taken from the same lot as that used in the barley and shorts mixture, but was not fed in such liberal quantities. The variations in the composition of the manure from each period were slight. A little over 24 pounds of manure was made, or an average of four pounds per day. All of the important data in connection with this experiment will be found reported in the followfng table:

SUMMARY OF RESULTS.

Kind of Sample	Pounds of Dry Matter	Pounds of Ash	Pounds of Organic Mat'r	Pounds of Ether Extract	Pounds of Crude Protein	Pounds of Fiber	Pounds of Nitrogen Free Extrat	Pounds of Albuminoids
In 36 pounds barley.....	31.36	.834	30.42	.972	4.165	3.006	24.82	4.05
In manure.....	6.80	.79	6.01	.318	.779	1.531	3.38	.765
Amount digested..... ...	24.56	.045	24.4[illegible]	.554	3.386	1.475	21.44	3.285
Digestion Co-efficient.....	80.15	5.39	80.25	.654	81.42	48.74	86.56	81.

At the beginning of the experiment the pig weighed 271 pounds and at the close 274, the six pounds of barley per day being just about sufficient to maintain the live weight. The pig consumed 52 pounds of water, and voided 36 pounds in the dung and urine. The food contained 0.666 pounds of nitrogen; .123 pounds were retained in the dung, and 51

pounds in the urine, making a total recovery of 94.2 per cent of the nitrogen of the food.

The average fertilizer analysis of the dung and urine showed the following percentage compositions.

DUNG.		URINE.	
Nitrogen	.43	Nitrogen	2.05
Phosphoric acid	.70	Phosphoric acid	.16
Potash	.62	Potash	.10
Value per ton	$ 3.07	Value per ton	$ 7.30
Value per day	.006	Value per day	.0108

Total Value per day, $ .017

IV. CORN AND SHORTS.

Digestibility and Manurial Value.

The barrow selected for this experiment, a Yorkshire-Berkshire-Duroc Jersey, was of a more contrary disposition than the one used in the experiment with barley, and barley and shorts. The preliminary feeding showed that about half the food offered was refused. This necessitated the feeding of an amount of food equivalent to about half that consumed in the barley and shorts experiment. The daily ration of a little over five pounds was just sufficient to evenly maintain the weight of the animal. The food consisted of a mixture of equal parts of corn and shorts. having the following percentage composition:

	Water	Ash	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Extr't
Corn.....	11.73	1.46	3.88	11.25	2.28	69.40
Shorts.....	10.12	2.78	4.90	13.75	8.35	60.09

The experiment was carried on for seven days and during that time eighteen pounds of each were fed.

POUNDS OF EACH CONSTITUENT CONSUMED.

	Water	Ash	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Ex.	True Albuminoid
Corn.	2.106	262	.6984	2.0304	12.49	.4106	.....
Shorts.....	1.821	.501	.872	2.475	10.516	1.506	... .
Total.....	3.927	.775	1.57	4.505	23.306	1.916	4.194

The experiment was divided into two periods, but the dung from each period was uniform in composition, and the average of all the analyses showed the composition to be:

Water	Ash	Ether Extract	Crude Protein	Nitrogen Free Extract	Crude Fiber
70.92	14.79	4.00	15.62	45.59	20.00

During the experiment seventeen pounds of dung was evacuated and the seventeen pounds were composed of the following number of pounds of each constituent:

Water	Dry Matter	Ash	Ether Extract	Crude Protein	Nitrogen Free Ex.	Crude Fiber	True Albumin'ds
12.05	4.95	73.28	.198	.795	2.25	.99	.683

And when these undigested portions are taken from the amounts in the food, the amounts digested are obtained, from which the digestion co-efficients of the corn and shorts are found to be:

Dry Matter	Ash	Organic Matter	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Ex.	True Albpmin'ds
84.2	4.15	86.5	87.3	82.35	48.3	90.3	83.31

The barrow drank 51 pounds of water, and gave off in the dung and urine 30 pounds, leaving 21 pounds to be disposed of through the lungs, pores of the skin, or retained in the body. At the beginning pig weighed 236 pounds and at the close 235 pounds, daily weighing fluctuating about 2 pounds. The nitrogen in the urine amounted to .528 pounds, in the dung .135 pounds, making a total of .663 pounds, while the amount in the food was .658 pounds. The total recovery of the nitrogen was therefore a little over 100 per cent. All of the daily food consumed, 5⅐ pounds, was used up in supporting the machinery of the animal, leaving none of the food to allow for any material gain in flesh.

A fertilizer analysis of the fresh dung and urine showed them to have the following percentage composition:

DUNG.		URINE.	
Nitrogen	.80	Nitrogen	2.65
Phosphoric acid	1.20	Phosphoric acid	.20
Potash	.65	Potash	.15
Value per ton	$ 5.16	Value per ton	$ 9.45
Value per day	.006	Value per day	.0120
Total value per day,	$.018		

V. CORN.

Digestibility and Manurial Value.

A few weeks later the barrow that had been used in the corn and shorts experiments was changed to a ration of corn. By this time the animal had recovered from his previous contrary indisposition to digestion experiments, and was willing to eat a comparatively larger amount of corn than of corn and shorts. Some of the same corn was used as in the previous experiment. Forty-five pounds of feed were consumed and 12½ pounds of dung returned in one week. As usual the experiment was divided into two periods, the composition of the manure from each period was quite uniform, and so only the average results are recorded.

COMPOSITION OF DRY MANURE.

Water	Dry Matter	Ash	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Ex.
67.88	32.12	16.36	10.05	12.81	12.83	47.95

The number of pounds of each of these compounds in the food and in the manure are given in the following table, together with the percentage of each digested:

SUMMARY OF RESULTS—CORN DIGESTIBILITY.

Kind of Samples	Pounds of Dry Matter	Pounds of Organic Mat'r	Pounds of Ash	Pounds of Ether Extract	Pounds of Crude Protein	Pounds of Crude Fiber	Pounds of Nitrogen Free Ex'act	True Albuminoids
In forty-five pounds of Corn	39.72	39.07	.657	1.746	5.062	1.027	31.23	4.635
In 12½ pounds manure.	4.02	3.37	.657	.40	.51	.52	1.927	.465
Pounds digested	35.07	35.70	.....	1.35	4.55	.507	29.303	4.17
Co-efficient of digestibility	89.7	91.3	.....	77.6	89.9	48.7	93.91	89.

The most important point of these retults is that none of the ash of the corn was digested, and the amount lost in the urine was entirely at the expense of that already stored in the body.

The urine contained 2.05 per cent nitrogen and had a specific gravity of 1.0305, about the same as that of milk. The urine for the seven days contained .520 pounds of nitrogen while the dung contained .10 pound; the nitrogen in the food, .8 pound, exceeded that in the dung and urine by .18 pounds, showing that 22 per cent of the nitrogen of the food was retained in the body. At the beginning of the experiment the pig weighed 247 pounds; and at the close 255. The pig consumed in all 48 pounds of water, and voided in the dung and urine about 28 pounds.

The fertilizer analysis of the dung and urine showed the following composition:

DUNG.		URINE.	
Nitrogen	.82	Nitrogen	2.05
Phosphoric acid	.89	Phosphoric acid	.29
Potash	.70	Potash	.21
Value per ton	$ 3.76	Value per ton	$ 7.59
Value per day	.0033	Value per day	.0095

Total value per day, ... $.0128

VI. DIGESTIBILITY OF SHORTS.

In the experiments reported in this bulletin, the digestibilities of barley and shorts and of barley, were separately determined upon the same animal. From the data furnished by these two experiments, the digestibility of the shorts may be obtained by the usual method of difference. The digestibilities of corn and shorts, and of corn were also separately determined upon another animal, thus furnishing entirely different data for another determinrtion of the digestibility of shorts in the same way.

Before considering these results it is necessary to review briefly the conditions: In the experiments with barley and shorts, the pig was fed a very liberal ration of nearly ten pounds per day, and made rapid gains in weight; when barley alone was fed the ration was cut down to six pounds per day, and the pig made no appreciable gain. In the experiments with corn and shorts, a ration of 5⅐ pounds per day made no gain, while with six pounds of corn per day a noticeable gain resulted. With each set of experiments it will be observed that the conditions were intentionally varied; furthermore the pigs used for these experiments were of different breeds, of different dispositions, and of slightly different weights. Breed, live weight, individual characteristics, combinations of the shorts with other grains, and the quantity of the food fed are all factors so entirely different throughout, that the results obtained, for the digestibility of shorts, when compared, are under the most severe tests to which they could be subjected.

The results are as follows:

SHORTS—DIGESTIBILITY BY DIFFERENCE BETWEEN.

	Dry Matter	Ash	Crude Protein	Crude Fiber	Nitrogen Free Extract
Barley and Shorts and Barley	74	6.6	71	25	85.5
Corn and Shorts and Corn	79	4.1	76	48	88.

Except the fiber, the most extreme difference is five per cent for the dry matter and the protein, showing that the digestibility of the shorts was increased, when fed in combination with a more digestible grain, and under more favorable conditions.

Outline.—In the previous experiments with pigs the animals weighed on the average about 250 pounds. In the following experiments, growing pigs of about 150 pounds were used. The digestion work as here reported can be divided at this point. The object of this division will appear when the disposition of the food is discussed. In the following work the digestibilities of corn and bran, peas and bran, and peas, are given; this furnishes data for two determinations of bran. All of the experiments were divided into two and three periods each, and the results given are the averages of all of the analyses made, which in no case was less than six.

VII. CORN AND BRAN.—Digestibility.

SUMMARY OF RESULTS.

	Dry Matter	Ash	Organic Matter	Extract Ether	Protein Crude	Fiber Crude	Nitrogen Free Extract	True Albuminoids
Total pounds in 29 pounds food	25.59	1.15	24.44	1.34	3.84	1.97	17.29	3.53
Total pounds in dung	7.28	.864	6.36	.40	.83	1.36	3.76	.77
Total pounds digested	18.36	.28	18.08	.95	3.00	.60	13.52	2.76
Digestion Co-efficients	71.7	24 6	73.9	70.1	78.3	30.6	78.2	78.1

The food consumed consisted of a mixture of one half corn (ground) and one half bran; 29 pounds of this mixture was fed for one week, and 24 pounds of dung was returned in the same time. The pig consumed 56 pounds of water and voided 29 pounds in the dung and urine. The total nitrogen in the urine amounted to .22 pounds, in the dnng .14 pounds. There was .61 pounds of total nitrogen in the food. The pig weighed 141 pounds at the beginning of the experiment, and 150 at the close. The mixed bran and corn and the manure returned had the following compositions; the results for the manure are calculated to dry substance; the results on the bran and corn are for the mixture as fed:

	Water	Ash.	Ether Ext.	Protein	Fiber	N. Free Ex.
Bran and Corn	11.76	3.97	4.60	13.25	6.80	59.62
Manure	69.87	12.00	5.40	11.56	18.9	52.14

The average fertilizer analysis for the dung and urine gave the following results in percentages:

COMPOSITION AS VOIDED.

DUNG.		URINE.	
Nitrogen	.57	Nitrogen	1.57
Phosphoric acid	1.70	Phosphoric acid	.52
Potash	.70	Potash	.20
Value per day	$ .008	Value per day	$ .006
Value per ton	4.06	Value per ton	6.22

Value, Mixed, $5.10

VIII. PEAS AND BRAN.—Digestibility.

SUMMARY OF RESULTS.

	Dry Matter	Ash	Organic Matter	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Extract	True Albuminoids
Total pounds in 31 lbs. of bran and peas...	37.70	1.38	26.22	.913	5.71	2.65	16.92	5.49
Pounds in manure.....	5.80	.92	4.87	.232	.98	1.12	2.53	.77
Pounds digested.....	21.90	.46	21.33	.681	4.73	1.53	14.39	4.72
Digestion Co-efficients...	79.	33.5	81.3	74.5	82.7	57.6	85.	85.

The food consumed consisted of a mixture of ground peas and bran, half and half by weight; 31 pounds of this mixture was consumed in seven days; 26 pounds of urine and 37.45 pounds of dung were returned in the same time; 69 pounds of water was consumed and 55 pounds voided in the dung and urine. The food contained .91 pounds of nitrogen, the dung .15 pounds, urine .40 pounds. The pig weighed 135 pounds at the beginning and 138 at the close.

The composition of the peas and bran as fed, and of the dry dung are as follows:

	Water	Ash	Ether Ex.	Fiber	Protein	N. Free	Album'ds
Peas.....	11.90	3.06	.85	7.46	21.69	55.04	20.62
Bran.....	9.40	5.95	5.05	10.25	15.18	54.17	14.81
Dung.....	84.50	15.90	4.00	19.40	17.00	43.7	14.07

The fertilizer compounds were present in the fresh dung and urine in the following percentages:

DUNG.		URINE.	
Nitrogen.....	.44	Nitrogen.....	1.54
Phosphoric acid.....	.94	Phosphoric acid.....	.35
Potash.....	.50	Potash.....	.10
Value per day.....	$.0075	Value per day.....	$ .01
Value per ton.....	3.20	Value per ton.....	5.80

IX. PEAS.—Digestibility.

SUMMARY OF RESULTS.

	Dry Matter	Ash	Organic Matter	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Extract	True Albuminoids
In 24 pounds of peas.....	21.15	.734	20.42	.204	5.20	1.79	13.209	4.95
In dung, pounds.....	2.16	.438	1.72	.104	.59	3.96	.628	.48
Digestible, pounds.....	18.99	.296	18.69	.100	4.61	1.39	12.56	4.46
Digestion Co-efficients...	89.8	40.3	91.5	(50)	88.6	77.9	95.08	90.

In this experiment the dung and urine were collected for only four and a half days. At the beginning of the experiment the pig weighed 152 pounds and at the close 151½. The confinement to a pea diet finally resulted in producing a diarrhœa. At this point the experiment was stopped.

X. BRAN.—Digestibility.

From the experiments on the digestibility of corn and bran, peas and bran, and peas, all of the data that are necessary are given for two determinations of the bran, one in combination with corn and the other with peas. When fed with corn the dry matter of the bran was only 53 per cent digestible, with peas 77 per cent.

This difference is too great to be overlooked, and would indicate, as in the case with shorts, that the per cent digested is materially influenced by two factors, viz: Combination in which it is fed, and peculiarities of the animal to which it is fed.

In reviewing the factors given by different investigators on the digestibility of bran, results will be found that vary as much as the ones here given. One factor that always tends to make a disagreement for bran co-efficients, is the variations in the composition of the samples of bran, due to the differences in the completeness of the milling process. and the character of the wheat.

The digestion results that are obtained from a bran from which everything is removed that possibly can be, are not applicable to a bran in which variable quantities of the interior of the grain are left. A chemical analysis of these two kinds of bran, alone, cannot be taken as a safe guide in determining this point, and to apply digestion co-efficients to such brans would be even more impossible. In the following table are given the results of analyses of samples of bran and shorts, from different grades of wheat in which the milling process was not as complete as for the bran and shorts used in these experiments. The low per cent of the protein in some of these samples is due entirely to the incomplete removal of the starch in the flour. These samples are usually considered of more value as feed, on account of the flour that

has not been removed, and if digestion co-efficients were applied to such samples the results would be far from the true value.

WHEAT BRAN—COMPOSITION OF ONE HUNDRED POUNDS.

Kind of Sample.	Water	Ash	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Extract	Albuminoids	Weight Grain per Bushel
Scotch Fife	10.59	6.37	4.30	13.43	11.20	54.11	13.12	63½
Blue Stem	10.82	6.01	4.60	15.00	12.60	50.97	14.37	59
Ladoga	10.97	6.78	4.40	12.81	12.61	50.53	12.50	57
Scotch Fife	10.32	6.13	5.02	14.43	10.57	53.53	14.06	61¼
Scotch Fife bleached	10.65	6.53	5.31	13.75	11.00	52.76	13.43	60
Scotch Fife badly bleac'd	10.24	6.12	5.60	16.12	10.32	51.60	15.56	57½
Scotch Fife frosted	10.40	5.48	4.12	13.89	10.50	55.61	13.50	58½
Scotch Fife badly frosted	10.33	5.82	4.03	15.62	15.00	55.12	15.00	58

SHORTS—COMPOSITION OF ONE HUNDRED POUNDS.

Scotch Fife	10.12	4.30	4.00	11.62			11.43	63½
Blue Stem	10.40	3.80	3.75	14.25			13.75	59
Ladoga	9.21	4.40	3.30	11.25			10.60	57
Scotch Fife	10.24	2.25	2.75	12.12			11.37	61¼
Scotch Fife bleached	10.42	2.40	2.92	10.87		n	10.31	60
Sc'ch Fife badly bleached	10.89	2.18	2.65	11.62			11.25	57½
Scotch Fife frosted	10.62	2.40	2.50	10.06			9.62	58½
Scotch Fife badly frosted	10.34	3.25	2.95	12.08			11.87	58

SUMMARY OF DIGESTION CO-EFFICIENTS.

Kind of Grain.	Dry Matter	Ash	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Extract	Albuminoids
Corn and Shorts.	84.2	4.15	87.3	82.4	48.3	90.3	81.3
Corn	89.7		77.6	89.9	48.7	93.9	89
Shorts	79	4.15		76	48	88	
Barley and Shorts	77.6	6.09	78.9	77.7	34	85.9	77.1
Barley	80.1	5.39	67.3	81.4	48.7	86.6	81
Shorts	74	6.63		71	25	85.5	
Corn and Bran	71.7	24.6	70.1	78.3	30.6	78.2	78.1
Bran	53.7		65.4	75.8	26.9	56	
Peas and Bran	79	33.5	74.5	82.7	57.6	85	85
Peas	89.8	40		88,6	77.9	95	90
Bran	77.8	30.1	78.1	74.4	39.1	75	75.8

In order to form some idea of the comparative value of these grains it is necessary to take into consideration the chemical composition as well as the digestibility. The chemical analyses show how many pounds of ash, fiber and protein there are in a hundred pounds of the grain or fodder. The digestibility is simply the amount that is digestible. The corn, for example, was found to be composed of 11.25 per cent of protein or 11.25 pounds of protein in every hundred pounds of the corn. This protein was found to be 89.9 per cent digestible, and in 11.25 pounds of protein there are 11.25 times .899 or 10.11 pounds of digestible protein in every hundred pounds of the corn. In like manner the pounds of digestible organic matter, fiber and other compounds are calculated.

In the following table the percentage composition of each grain is given, and then the number of pounds of digestible organic matter, fiber and protein in every hundred pounds of the grain as fed:

Kind of Grain.	Dry Matter		Organic Matter		Ether Extract		Crude Protein		Crude Fiber		N. Free Extract		Nutritive Ratio
	Pounds per Hundred	Pounds Digestible	Pounds per Hundred	Pounds Digestible	Pounds per Hundred	Pounds Digestible	Pounds per Hundred	Pounds Digestible	Pounds per Hundred	Pounds Digestible	Pounds per Hundred	Pounds Digestible	
Corn.....	88.28	79.18	86.82	79.26	3.88	3.01	11.25	10.11	2.28	1.11	69.40	65.16	7.2
Corn & Shorts.	89.08	75.00	86.89	75.14	4.39	3.83	12.00	10.29	5.31	2.56	64.73	58.22	6.8
Barley.....	88.22	70.71	85.90	69.01	2.70	1.86	11.57	9.42	6.00	2.92	65.63	56.82	6.6
Barley&Shorts	89.00	69.08	86.45	68.90	3.80	3.06	12.66	10.00	7.18	2.44	63 86	54 45	6.4
Shorts,average	89.88	68.76	87.09	.....	4.90	.....	13.75	10.11	8.35	3.09	60.09	52.20	6.5
Corn and Bran	88.24	63.27	84.27	62.17	4.60	3.22	13.25	10.37	6.8	2.08	59.62	46.62	5.5
Peas and Bran	89.35	70.58	84.84	68.97	2.95	2.21	18.54	15.38	8.86	4.66	54.50	56.32	3.6
Peas.....	88.10	79.11	84.04	76.85	.85	.42	21.69	19.22	7.46	4.30	55.04	46.78	3.2

COMPARISON OF THE MANURIAL VALUES.

In the following table the fertilizer value of the food consumed by each animal per day, and the corresponding values of the dung and urine are given, together with other important data, for a comparison of the manurial values:

Kind of Food	Pounds of food per day	Per cent of nitrogen retained in body	Fertilizer Value of the food consumed	Value of the urine per day (Cents)	Value of the dung per day	Total Value per day	Initial weight of pigs
Barley and Shorts	9 5-7	35	.043	.016	.012	.028	254
Barley	6	6	.02	.010	.006	.016	275
Corn and shorts	5 1-7	0	.021	.012	.006	.018	235
Corn	6½	22	.016	.010	.003	.013	258
Peas and Bran	4 3-7	28	.....	.01	.007	.017	135
Corn and Bran	4 1-7	25	.....	.008	.006	.014	141

The value of the manure returned in one day, it will be seen, depends upon the quantity and kind of food and the per cent of nitrogen retained in the body. The dung returned from a hundred pounds of the barley is more valuable than that returntd from a hundred pounds of the corn. The addition of shorts to either barley or corn very noticeably increased the value of the dung.

The money values assigned to the mixed dung and urine are much greater than the actual returns would be to the farmer; and the results in order to conform to his conditions should be divided at least by three and possibly four, since ordinarily all the urine is lost, which in these experiments amounts to over half the value of the dung. A farther and additional loss occurs from drainage before the dung is spread in the fields.

THE NITROGEN IN THE FOOD SUPPLY.

COMPARISON OF RESULTS.

In the following table the important data in connection with the nitrogen of the food supply, and the amounts returned in the dung and urine, will be found, together with the amounts retained in the body.

Kind of Food.	Pounds of food per day	Initial weight of pigs	Total lbs of nitrogen per week in				Pounds per day of digestible protein in food	Pounds of gain per week
			Food	Dung	Urine	Retai'd in body		
Barley and Shorts	9 5-7	254	1.37	.32	.57	.48	.95	19
Barley	6	271	.76	.14	.58	.04	.56	3
Corn and Shorts	5 1-7	236	.66	.14	.53	.00	.52	loss 1½
Corn	6½	247	.80	.10	.52	.18	.75	8

It will be seen that when no nitrogen was retained in the body there was a slight loss of weight, and when only a small quantity of nitrogen was retained a slight gain resulted. An increase in weight will be found to be accompanied by an increase of the nitrogen stored up in the body. With about half a pound of digestible protein per day in the food, the pigs fed on barley, and corn and shorts made no appreciable gains, but when the digestible protein was increased to three quarters of a pound per day, and the other compounds increased in the same ratio, the pig made a fair gain, and when the amount was still farther increased to nearly a pound per day the pig gained nineteen pounds in a week. From the table it will be seen that a little over half a pound of nitrogen per week was passed in the urine of each animal, and this occurred whether the animal was gaining or losing in weight. The amount of nitrogen carried off in the dung varied according to the amount of undigestible nitrogen to be disposed of in the food. The nitrogen in the urine repre-

sents nearly all of the digestible nitrogen of the food that was used in the body for mechanical purposes, while the nitrogen in the dung represents mainly the indigestible nitrogen of the food.

When the digestible nitrogen in the food was increased above the amount required to maintain the animal, nearly all of this increase was stored up in the body.

To the farmer these results mean that for every six and one-half pounds of barley or corn fed to a pig weighing 250 pounds, about six pounds are used up mechanically, in the body, and only about half a pound goes to make flesh. The chief benefits that are derived from the food, comes from the small amount that is in excess of that required for maintenance. These figures show how unprofitable it is to deal out small or unbalanced rations for fattening mature animals since a certain amount must go for supplying fuel and doing work, and nearly all above this amount is made into flesh. It is economical to feed a liberal ration.

University of Minnesota.

Agricultural Experiment Station.

BULLETIN No. 27.

CHEMICAL DIVISION.

FEBRUARY, 1893.

I. THE COMPOSITION OF FODDERS, WHEAT AND MILLED PRODUCTS.

II. THE COMPOSITION OF DAIRY PRODUCTS.

III. SUGAR BEETS.

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I. THE COMPOSITION OF FODDERS AND GRAINS.

BY HARRY SNYDER.

A. WHEAT AND MILLED PRODUCTS.

During the year 1892 a number of analyses have been made of different grades of wheat, together with the flour and products obtained from them. These samples represent a number of different grades of wheat from the crop of 1891. No attempt is made to distinguish between the different commercial grades of wheat as to chemical composition, since this would require a larger number of analyses than have yet been made. The results are given, as they show fairly well the average composition of wheat as grown in Minnesota. These analyses show that these samples are much richer in gluten and other valuable food compounds than the average as generally given for American wheat.

The results are expressed in percentages, or parts per hundred. In the table the averages are first given, then the extremes or highest and lowest percentages. The starch and dextrin (soluble starch) were separately determined in each sample. In the flour, sixteen samples are reported. The flour was made from eight of the eighteen samples of wheat whose analyses are reported, and contains more starch and less gluten and nitrogenous matters than the original wheat. The small amount of ether soluble matter (mainly fat) is noticeable. In the wheat, it will be seen that the ratio of the gluten to the starch is about 1 to 4; in the flour 1 to 6.5.

The composition of the wheat germ is extremely interesting, inasmuch as there is more nitrogenous matter in this product than in the original wheat or any of the other

products. This is quite suggestive. The germ is too valuable a food product to be incorporated into the by-products. The shorts and bran reported are not from the same milling as the wheat, flour and germ. They represent, however, the average composition of bran from exhaustive milling. The shorts contain less nitrogen, ash and fiber than the bran; these same compounds in the shorts are, as a rule, more digestible than those of the bran. The reader is referred to bulletin 26 page 29 for a more complete discussion of the digestibility of bran and shorts.

It will be seen on examining the table, that on the average there is more water in the flour and each one of the products, than was present in the original wheat. Whether this is true in general yet remains to be seen. Wheat starch is quite hydroscopic, and without doubt many of the discrepancies in the weighings of large quantities of wheat are due to the differences in the amounts of hydroscopic moisture present. A difference of one-half of one per cent of water would make a difference of a half a pound on a hundred pounds of wheat. A difference of half of a per cent of water in the same sample of wheat at different times is not an uncommon occurrence. In the wheat 97 per cent of the nitrogen is in the form of gluten and other albuminoids; in the flour 98. Practically all of the nitrogen is in the form of gluten and albuminoids. This is not in accord with statements found in many chemical journals and books, but it must be remembered that the chemical methods for the determination of nitrogen have been materially improved within comparatively recent years.

The per cent of starch and dextrin in the wheat ranged from 62.4 to nearly 68, with an average of about 65. The starch and gluten make up about 90 per cent of the total composition of the dry organic matter of the wheat. The extremes reached in the composition of these wheats were marked by the Ladoga wheat. It contained the most mineral matter, fiber (woody material) and the least gluten of any of the wheats examined; and the same was true of the Ladoga flour.

WHEAT AND ITS MILLED PRODUCT.

Kind of Sample.	Number of Samples	Water	Ash	Ether Extract	Protein.		Starch and Dextrin	Undetermined	Fiber
					Total	Gluten			
Wheat (1891)—									
Average ...	18	10.16	1.84	2.01	13-75	13.50	64.90	4.14	3.20
Highest ...		12.10	2.10	2.26	14.12	14.01	67.86	5.64	4.32
Lowest.....		9.61	1.61	1.71	10.10	9.37	62.40	1.71	2.90
Flour—									
Average ...	16	10.63	.45	.55	11.25	11.00	70.39		
Highest....		13.98	.76	.71	13-35	13.05	74.00		
Lowest.....		9.53	.35	.34	6.88	6.81	68.80		
Wheat Germ—									
Average....	8	10.41	2.74	3.50	15.74	15,31			
Highest....		10.98	3.33	5.00	18.75	18.42			
Lowest.....		10.32	2.51	3.01	13.75	13.13			
Wheat Shorts—							Nitrogen free extract.		
Average....	6	10.12	3.12	2.90	13.11	12.87	65.33		5.42
Highest....		14.12	4.40	4.00	14.16	13.70	68.80		6.98
Lowest.....		9.04	2.18	2.41	10.06	9.68	61.60		4.12
Bran—									
Average....	5	10.40	5.95	5.05	15.38	14.81	52.87		10.25
Highest....		13.12	6.25	5.62	18.12	17.64	59.80		14.8
Lowest.....		9.40	4.87	4.37	12.16	11.81	50.04		7.12

B. FODDER PRODUCTS OF CORN.

The composition of corn ensilage, corn, corn and cob meal and the tops and butts of corn stalks are given in tabular form. In the case of ensilage the results are the averages of duplicate analyses of eight samples. For the sake of a uniform basis for comparison, the composition of corn stalks, with and without the grain, and of ensilage, is given in terms of the dry matter (water free basis.) Comparing the composition of corn and of corn and cob meal, it will be seen that there is more fiber (woody material,) more ash, less protein and ether extract in the corn and cob meal than in the corn meal. Comparing the composition of the tops and butts of corn stalks, it will also be seen that there is about the same difference, namely: more fiber and ash in the butts than in the tops. The tops are richer in the more valuable food materials than the butts.

The composition of the dry matter of ensilage is practically the same as the composition of the stalks with the grain, when cured as dry corn fodder.

In the corn ensilage 88 per cent of the total nitrogen is in the form of albuminoids; in the corn and stalks about 90 per cent. The corn and corn and cob meal are not strictly comparable as to this point, since they are not from the same corn. As a rule, the more nitrogen there is present in the form of albuminoids the more valuable the fodder.

FODDER PRODUCTS OF CORN.

COMPOSITION EXPRESSED IN POUNDS PER HUNDRED.

Kind of Sample.	Number of Samples.....	Water.....	Ash.....	Ether Extract	Protein.		Nitrogen Free Extract.....	Crude Fiber...	Nitrogen in form of Albuminoids..
					Total.....	Albs.....			
Corn Ensilage—									
Average....	8	73.85	1.41	.89	1.96	1.73	13.88	6.28	88%
Highest.....		77.21	1.47	.95	2.22	1.79	16.00	6.51	
Lowest.....		71.00	1.20	.84	1.89	1.65	12.00	6.17	
Corn (whole kernel)—Average....	5	10.73	1.46	3.88	10.25	9.60	70.4	2.25	93%
Highest.....		11.75	1.49	4,16	11.25	10.20	72.01	2.30	
Lowest.....		10.60	1.42	2.88	9.92	9.01	68.80	2.10	
Corn and cob meal									
Average....	4	6.48	1.65	3.65	7.56	7.22	70.55	10.11	95%
Highest.....		10.16	1.69	3.79	7.84	7.71	74.80	11.63	
Lowest.....		5.12	1.61	3.41	7.41	7.05	68.24	9.83	

IN THE FOLLOWING SAMPLES THE RESULTS ARE GIVEN ON DRY MATTER.

Corn Stalks, (no grain).....	2	6.25	1.90	4.30	3.88	54.17	29.20	90%
Corn Tops.....	1	5.80	2.01	5.01	4.82	59.24	25.12	96%
Corn Butts.....	1	7.06	1.46	4.03	3.60	51.44	32.41	89%
Stalks with Corn..		5.00	3.45	7.61	6.84	52.09	25.00	90%
Corn Ensiiage.....		5 04	3.43	7.52	6.12	53.39	24.00	88%

C. MISCELLANEOUS GRAINS AND FODDERS.

Comparing the average composition of barley with that of oats, it will be seen that oats contain more fiber, ash and ether extract, the average amount of protein in each being about the same. The peas are characteristically rich in nitrogenous compounds; gluten meal is even more so; while

germ meal is richer than ordinary grain. The flax seed is rich in both the fat and the albuminoid compounds. The average per cent of the total nitrogen in the form of albuminoids is the same for both the oats and the barley, viz: 94. It would appear that there is but little amide nitrogen in the grains. This is of great importance since the amide compounds are considered to have a lower food value than the albuminoid compounds. In calculating crude protein no distinction is made between amide and albuminoid nitrogen. With ordinary grains this does not seriously affect the results. Hence but little or no correction is necessary for non-albuminoid nitrogen in wheat, flour, oats, barley, corn, gluten meal and flax seed; with the hay and straw this does not hold true, as a reference to the table will show.

The per cent of ash in the wheat straw, oat straw, timothy and millet appears incredibly large when compared with older analyses. In the older analyses, the insoluble silica and carbon dioxide were deducted from the ash. In the case of all of the above samples this seriousiy affects the per cent of ash, since in the case of wheat straw nearly half the ash is insolubie silica (sand); and if this insoluble silica was deducted from the ash, the wheat straw would contain about 4.50 per cent ash, instead of 9. The total, soluble and insoluble silica were determined in each sample, and since they compose such a large per cent of the mineral matters of the straw, they are interesting to observe:

	Wheat Straw.	Oat Straw.	Timothy.
Total Silica	57.95	45.25	46.65
Insoluble Silica	48.7	41.76	44.62
Soluble Silica	9.25	3.49	2.03

This also affects the per cent of nitrogen free extracts in these samples from 3 to 4 per cent, making the samples so much less valuable. Nitrogen free extract is a very broad term, and at one time it included a little sand.

Among the miscellaneous fodder articles timothy, millet and ths straws will be found to be poor in protein compared with clover, pea hay and lucern. The plants that are rich in

nitrogenous compounds are frequently called the nitrogenous plants; clover, lucern and pea hay are good examples of such fodders. Pea hay compares closely and favorably with clover hay; pea hay is extremely rich in mineral matter. Wolff, in his "Aschen Analysen," gives average results of analyses with even higher percentages of ash. Pea hay ash is rich in lime, phosphoric acid and potash, all essential materials for bone growth in young and growing animals. In bulletin No: 26, page 12, it will be found that the ash is quite completely digested by milch cows.

Millet and timothy hay are quite similar in composition, with the advantage as far as protein is concerned, in favor of millet. The dry matter of the rape, particularly of the leaves, is rich in nitrogenous compounds. Attention should be given to the raising of fodders that contain more of the albuminoid compounds.

With the exception of the wheat the grain and fodder crops reported were grown upon the experiment station farm during the seasons of 1891 and 1892. A number of these fodder articles can be added, to advantage to many farmers' crops.

GRAINS AND SEEDS.

Kind of Sample.	Number of Samples	Water	Ash	Ether Extract	Protein.		Nitrogen Free Extract	Fiber	Per cent of total Nitrogen in form of Albumin'ds
					Total	Albumenoids			
Barley—									
Average	4	11.78	3.32	2.70	11.57	10.92	67.63	3.00	94
Highest		13.60	2.64	2.98	13.60	13.16	68.80	5.12	
Lowest		9.80	2.12	2.41	10.12	9.58	62.12	4.48	
Oats—									
Average	5	8.60	3.62	4.88	11.70	11.01	60.94	6.64	94
Highest		9.43	3.38	5.32	11.84	11.71	62.99	11.70	
Lowest		8.09	2.85	4.12	10.14	9.84	61.34	5.64	
Flax Seed	1	5.10	3.54	38.60	27.50	26.12	19.24	7.40	95
Germ Meal	1	6.52	1.25	6.47	14.00	13.01	63.71	8.25	93
Gluten Meal	1	9.02	.87	7.62	27.46	25.40	55.64	1.39	93
Peas—									
Average	4	9.84	3.40	1.03	22.00	21.05	58.00	5.73	96
Highest		11.90	3.62	1.16	23.04	22.12	59.60	7.46	
Lowest		9.72	3.06	.85	21.69	21.02	55.04	5.64	
Buckwheat (wild)	1	11.92	2.65	3.25	10.60	8.42	60.81	10.77	

HAY, STRAW AND MISCELLANEOUS.

Kind of Sample.	Number of Samples	Water	Ash	Ether Extract	Protein.		Nitrogen Free Extract	Crude Fiber	Per cent of total Nitrogen in form of Albumin'ds.
					Total	Albumin-oids			
Wheat Straw	1	7.41	9.22	.97	3.25	2.50	38.27	40.88	71.4
Oat Straw	1	8.36	9.00	1.40	4.06	2.90	41.11	38.07	70.
Clover Hay	1	10.25	6.45	2.59	13.43	12.00	42.64	24.67	89.
Timothy Hay	1	10.17	5.64	1.60	5.62	4.80	44.56	32.41	85.
Millet Hay	1	7.65	9.33	1.55	6.68	5.98	43.79	31.00	88.
Lucern Hay	1	10.12	6.91	2.10	13.54	12.02	39.13	28.20	89.
Rape, dry (whole plant)	1	84.51	7.60	1.80	11.75	7.18	63.56	15.29	61.
Rape, dry leaves	1	88.16	7.50	3.20	17.04	13.09	60.03	11.06	75.
Pea Hay	1	9.75	12.72	2.63	14.58	12.25	32.86	27.46	84.

II. THE COMPOSITION OF DAIRY PRODUCTS.

A. MILK.

General Composition.—Milk is composed of water and solid matter. The milk solids obtained by evaporating milk to dryness at the temperature of boiling water form a light brown, shiny, brittle mass, made up of four classes of compounds, viz: Fats, sugar, nitrogenous matters such as casein, albumen and ash. The fats, nitrogenous matters and ash are each in their turn made up of a number of compounds; the ash, for example, is partially composed of common salt, lime and potash. A complete analysis of milk usually means nothing farther than a determination of the percentage amounts of each class of compounds such as the fats, ash, and milk sugar, that are present, and not a separation of these groups into simpler compounds. Milk is extremely complex in its composition and to separate a sample into the twenty-four or more compounds of which it is composed is the labor of a number of days.

Milk fats are familiar to every one as the product recovered in the butter. A pound of butter contains only about .85 of a pound of pure milk fats, the remaining .15 being made up of water, casein, salt and other matters.

Pure milk sugar in appearance resembles ordinary confectionery sugar; the milk sugar of commerce usually has a yellowish hue due to impurities. Since it is not sweet to the taste it is quite unlike cane sugar.

The nitrogenous matters in milk are extremely complex and

comprise the casein and albumen groups. The casein is commonly known as the curd. The albumen in milk is not recovered in either butter making or ordinary cheese making.

During the past year approximate analyses have been made of the milk from the individual cows. Some of the results are given in the following tables, and show the daily composition of the milk of different cows for periods of 1 week. At the time these samples were taken the cows were all in about the same condition, their food was practically uniform, and hence the differences in composition and yield are due mainly to breed and individuality.

The quantity of milk yielded is equally as important in determining the value of a cow as the percentage composition or quality. Either factor taken alone possesses but little value, but when taken together they determine the total yield of fats or solids for that particular period. In the tables will be found both the daily percentage composition of the milk, and under the headings "yield per day" the total number of pounds of solids, ash, casein, sugar, and fat in the two milkings for that particular day.

The figures in heavy type at the end of each separate table are the averages for that particular cow.

BECKLEY.

Per Centage Composition.					Yield Per Day in Pounds.					
Solids.....	Fat.....	Ash.....	Casein.....	Sugar.....	Solids.....	Fat.....	Ash.....	Casein.....	Sugar.....	Milk.....
14.80	6.00	.69	3.56	4.46	2.83	1.14	.13	.68	.85	19.1
14.09	5.45	.67	3.47	4.50	2.77	1.07	.13	.68	.89	19.7
14.79	5.20	.68	4.01	4.90	2.99	1.05	.14	.88	.99	20.2
14.89	5.90	.67	3.62	4.65	2.92	1.06	.12	.71	1.02	19.7
14.61	5.40	.70	4.01	4.50	2.88	1.06	.14	.79	.88	19.7
14.64	5.30	.76	3.78	4.80	3.06	1.10	.16	.79	.99	20.9
14.98	5.75	.77	3.56	4.99	2.93	1.13	.15	.70	.96	19.6
14.70	**5.57**	**.71**	**3.71**	**4.67**	**2.91**	**1.09**	**.14**	**.75**	**.94**	**20.**

GERTIE.

15.24	6.50	.72	3.17	4.85	2.96	1.26	.14	.61	.94	19.4
14.89	5.80	.69	3.45	4.90	3.25	1.26	.15	.75	1.07	21.8
15.13	5.40	.78	3.90	5.05	3.37	1.20	.17	.87	1.15	22.3
14.88	5.25	.78	3.85	5.00	3.18	1.12	.17	.82	1.07	21.4
14.87	5.30	.74	3.98	4.85	3.19	1.14	.16	.85	1.04	21.5
15.13	5.10	.78	4.20	5.05	3.36	1.13	.17	.93	1.13	22.2
14.68	5.50	.76	3.35	5.1	3.19	1.19	.16	.72	1.10	21.7
14.97	**5.55**	**.75**	**3.70**	**4.97**	**3.21**	**1.19**	**.16**	**.79**	**1.07**	**21.4**

OLIVE.

Per Centage Composition.					Yield Per Day in Pounds.					
Solids.....	Fats.....	Ash.....	Casein.....	Sugar.....	Solid.....	Fat.....	Ash.....	Casein.....	Sugar.....	Milk.....
12.71	4.7	.64	3.07	4.30	4.32	1.6	.22	1.04	1.46	34.
12.18	3.9	.69	3.09	4.50	4.35	1.37	.25	1.10	1.60	35.7
12.52	3.8	.62	3.10	5.05	4.42	1.35	.22	1.10	1.78	35.4
12.40	3.8	.60	3.00	5.00	4.34	1.33	.21	1.05	1.75	35.
12.36	4.0	.64	3.02	4.70	4.36	1.41	.23	1.06	1.65	35.3
12.76	4.0	.66	3.00	5.10	4.53	1.42	.24	1.06	1.81	35.5
12.89	4.4	.64	3.00	4.85	4.63	1.58	.23	1.07	1.74	35.9
12.56	**4 09**	**.64**	**3.04**	**4.78**	**4.42**	**1.44**	**.23**	**1.07**	**1.68**	**35.2**

REDDY.

13.97	5.45	.66	3.36	4.50	3.19	1.25	.15	.77	1.03	22.9
13.80	5.10	.63	3.22	4.85	3.87	1.43	.18	.90	1.36	21.8
13.34	5.00	.61	3.03	4.70	3.25	1.22	.15	.74	1.15	24.4
14.01	4.95	.65	3.46	4.95	3.24	1.14	.15	.80	1.14	23.1
14.24	5.30	.65	3.54	4.75	3.37	1.22	.15	.83	1.10	23.1
14.34	5.00	.70	3.59	5.05	3.20	1.11	.15	.80	1.13	22.3
13.63	4.40	.65	3.68	4.90	3.23	1.04	.15	.87	1.16	23.7
13.91	**5.03**	**.65**	**3.41**	**4.81**	**3.34**	**1.20**	**.15**	**.81**	**1.15**	**23.**

ROSSIE.

12.69	4.20	.64	3.25	4.60	2.73	.90	.14	.69	.99	21.5
12.73	3.7	.60	3.32	4.90	3.09	.89	.14	.79	1.26	24.
13.01	3.8	.59	3.62	5.00	2.92	.85	.14	.81	1.12	22.5
12.64	3.45	.62	3.62	4.95	2.84	.77	.14	.81	1.11	22.5
12.80	3.7	.67	3.63	4.80	3.20	.92	.16	.91	1.20	25.3
12.86	3.9	.63	3.28	5.05	3.11	.95	.15	.80	1.23	24.3
12.90	4.00	.62	3.48	4.80	3.47	1.07	.16	.92	1.28	26.9
12.80	**3.82**	**.62**	**3.46**	**4.87**	**3.05**	**.91**	**.15**	**.82**	**1.03**	**23.8**

ROXY.

13.59	5.05	.67	3.17	4.60	4.41	1.64	.22	1.03	1.49	32.5
13.32	4.55	.63	3.09	5.05	4.88	1.67	.23	1.13	1.85	36.7
13.25	4.10	.65	3.35	5.15	4.38	1.36	.21	1.10	1.70	33.1
13.33	4.35	.66	3.22	5.10	4.61	1.50	.23	1.09	1.76	34.6
13.21	4.05	.67	3.39	4.95	4.52	1.38	.23	1.17	1.69	34.2
13.20	4.20	.70	3.20	5.10	4.75	1.51	.25	1.15	1.87	36.0
12.83	4.20	.67	3.06	4.90	4.70	1.43	.24	1.12	1.80	36.7
13.25	**4.33**	**.67**	**3.21**	**4.97**	**4.61**	**1.50**	**.23**	**1.11**	**1.74**	**34.7**

SWEET BRIAR.

Per Centage Composition.					Yield Per Day in Pounds.					
Solids.....	Fat.....	Ash.....	Casein.....	Sugar.....	Solids.....	Fat.....	Ash.....	Casein.....	Sugar.....	Milk.....
14.55	5.00	.67	3.88	5.00	4.23	1.45	.20	1 13	1.45	29.1
13.75	4.80	.62	3.52	4.80	4.37	1.52	.20	1.12	1.52	31.8
13.76	4.60	.65	3.38	4.95	4.57	1.52	.21	1.23	1.64	33.2
13.47	4.40	.68	3.29	5.10	3.91	1.27	.20	.95	1.47	28.9
13.81	5.00	.72	3.39	4.70	4.46	1.61	.23	1.06	1.52	32.3
13.58	4.50	.72	3.11	5.25	4.28	1.42	.22	.98	1.62	31.5
14.00	5.00	.70	3.34	5.00	4.48	1.60	.22	1.05	1.60	32.0
13.85	**4.76**	**.68**	**3.41**	**4.97**	**4.33**	**1.49**	**.22**	**1.07"**	**1.54**	**31.2**

TRIXY.

13.07	4.6	.68	3.19	4.60	4.18	1.47	.22	1.02	1.47	32.
13.21	4.95	.60	3.00	4.65	4.49	1.68	.20	1.02	1.58	34.
13.24	4.80	.70	3.09	4.65	4.63	1.68	.24	1.08	1.53	35.
13.84	5.00	.72	3.15	4.95	4.39	1.58	.23	1.00	1.58	31.7
14.61	4.80	.71	3.90	5.20	4.89	1.60	.24	1.30	1.74	33.5
13.09	4.25	.68	3.66	4.50	4.24	1 37	.22	1.18	1.45	32.4
13.00	4.25	.68	3.37	4.70	4.25	1.47	.22	1.09	1.53	32.7
13.44	**4.66**	**.68**	**3.34**	**4.75**	**4.44**	**1.55**	**.22**	**1.10**	**1.55**	**33.**

THE AVERAGE COMPOSITION OF THE MILK FROM EACH COW FOR FOURTEEN MILKINGS.

Name of Cow.	Per Centage Composition.					Yield Per Day in Pounds.					
	Solids	Fats	Ash	Casein	Sugar	Solids	Fat	Ash	Casein	Sugar	Milk
Beckley	14.70	5.57	.71	3.71	4.67	2.91	1.09	.14	.75	.94	20.0
Gertie	14.97	5.55	.75	3.70	4.95	3.21	1.19	.16	.79	1.07	21.4
Olive	12.56	4.09	.64	3.04	4.78	4.42	1.44	.23	1.07	1.68	35.2
Reddy	13.91	5.03	.65	3.41	4.81	3.34	1.20	.15	.81	1.15	23.0
Rossie	12.80	3.82	.62	3.46	4.87	3.05	.91	.15	.82	1.03	23.8
Roxy	13.25	4.33	.67	3.21	4.97	4.61	1.50	.23	1.11	1.74	34.7
Sweet Briar	13.85	4.76	.68	3.41	4.97	4.33	1.49	22	1.07	1.54	31.2
Trixy	13.44	4.66	.68	3.34	4.75	4.44	1.55	.22	1.10	1.55	33.0
General Average	13.68	4.74	.67	3.42	4.85	3.79	1.30	.19	.94	1.35	27.8

On examining the table it will be seen that when an ordinary cow produces a pound of butter fat, she produces at the same time a little more than a pound of milk sugar, about .8 of a pound of casein and albumen, and nearly .15 of pound of minerals.

These analyses represent the daily composition of the milk from eight cows for a period of one week or the analyses of 112 samples of milk.

	Average Composition.	Highest.	Lowest.
Water	86.32	84.76	87.82
Dry Matter	13.68	15.24	12.18
Fats	4.74	6.50	3.45
Casein, etc	3.42	4.20	3.00
Milk Sugar	4.85	5.25	4.30
Ash	.67	.78	.59

The average composition of forty-three samples of milk purchased for the purpose of making cheese during the winter of 1892, shows a somewhat lower percentage composition, and probably represents more nearly the average throughout the state:

Water	12.80	Casein, etc	3.57
Dry Matter	87.20	Milk Sugar	4.85
Fats	3.65	Ash	.71

The use of the lactometer and milk test in determining the character of milk.—The specific gravity of normal milk ranges from 1.029 to 1.035. The ash, casein and milk sugar are the compounds that increase the specific gravity while the fat tends to decrease it. In normal milk there is a point where these two opposite forces neutralize each other; hence any serious change in the composition of milk immediately affects its gravity. The addition of water lowers the gravity while the removal of the fat raises it. The specific gravity is usually taken with the lactometer, which should always be provided with a thermometer in the bulb, and whenever a reading is taken the temperature should be noted. Corrections are made for a high or low temperature by the table that usually accompanies the instrument. In using the lactometer and test jointly, the following general rules can be applied in cases of suspected adulteration:

1. A high specific gravity and a low fat indicates fat removed.

2. A low specific gravity and a low fat indicates watering.

3. An average specific gravity and a low fat indicates fats removed and watered.

These rules are not infallible but they will aid in detecting any of the ordinary forms of sophistication.

Another important use that can be made of the lactometer and test is in gaining an idea of the total solid matter in milk, and to meet this want a number of formulæ have been proposed. The most recent and trustworthy ones are those given by Fleischman, and Hehner and Richmonds.

Fleischman's formula is: $X = 1.2F + 2.665 \frac{100S - 100}{S}$ in which X = the total solids, F the per cent of fat and S the specific gravity. As a rule this rule gives results nearer those found by analyses than Hehner and Richmond's.

The solids found by calculation, using either formula, in the most extreme cases amounts to about .2 of a per cent, the average being about .1 of a per cent.

Hehner and Richmond's formula is: $F = \frac{5}{6}\left(T - \frac{G}{4}\right)$ from which the value of T is obtained; $T = 1\frac{1}{5}F + \frac{G}{4}$; in which T = the total solids, F the per cent of fat, and G the number indicated on the specific gravity spindle. If the per cent of fat is found to be 4.1 and the specific gravity 1.033 at 60°, applying the formula $4.1 \times 1.2 = 4.92$ and $33 \div 4 = 8.25$. The sum of 4.92 and 8.25 is 13.12, the per cent of total solids in the milk. This formula is simpler to apply and as a rule gives fairly approximate results.

B. BUTTER.

Twenty-seven samples of butter have been analyzed, in connection with various experiments during the year. The samples of butter represent the products from individual

cows, and also that from the whole herd. The percentage composition was found to be:

	Average.	Highest.	Lowest.
Water	12.22	16.20	8.21
Fat	85.00	90.20	79.42
Ash and Salt	2.10	3.03	.74
Casein, etc	.68	2.09	.21

Comparing these results with older analyses it will be seen that with improved butter making there is a tendency to incorporate less casein, water and other foreign matters with the butter. The tendency is thus to improve the keeping qualities of the product.

The butter made from cream separated by the DeLaval Danish Weston, and other centrifugals, is about the same in composition as butter made from the cold deep setting process. The average of duplicate churnings gave for the composition of the butter product from these various machines:

Water	10.42	Casein, etc	1.03
Fat	86.98	Ash and Salt	1.57

The examination of the product from the butter extractor showed the average composition of different churnings:

	Water.	Fat.	Casein.	Salt and Ash.
December 10	11 29	83.37	2.74	2.50
" 11	13.40	81.20	2.74	2.66
" 22	16.19	79.85	2.46	1.50
January 6	16.08	79.56	2.81	1.55

C. LOSSES OF MILK SOLIDS IN CHEESE MAKING.

A clearer understanding of this question can be gained by first following, in a general way, the solid matters in the milk through the process of cheese making.

A hundred pounds of milk ordinarily contains from 12.50 to 13 pounds of dry solid matter. This solid matter is composed of 3.5 to 4 pounds of milk fats, 3¼ to 3¾ pounds of casein and albumen, about 4.80 pounds of milk sugar, ¾ of a pound of ash, and at the time the rennet is added there is

about .15 of a pound of lactic acid. When the whey is drawn off and weighed there is from 85 to 88 pounds of whey for every hundred pounds of milk.

While the milk is in the vat, about two pounds of water are lost by evaporation, for every hundred pounds of milk, the amount lost depending upon the temperature and condition of the atmosphere of the cheese room.

Of the 12.5 to 13 pounds of solids in the milk from 6 to 6.3 pounds are lost in the whey, so that but little more than half of the solids in the milk are recovered in the green cheese. From .28 to .34 of a pound of fat is lost out of the 3.50 to 4 pounds in the milk. The nitrogenous matters (casein and albumen) are not so economically recovered as the milk fats; of the 3¼ to 3¾ pounds of casein and albumen in the milk, about .8 of a pound is lost in the whey, mainly albumen which is not coagulated by the rennet, and is a very valuable food product. But little of the milk sugar is retained in the cheese, and out of the 4.8 pounds originally present in the 100 pounds of milk, from 4.30 to 4.60 are lost in the whey. Hence the solid matter recovered in the cheese is composed mainly of fats and casein. When the milk solids are increased, the amount recovered in the green cheese is increased, while the amount of solid matter lost in the whey remains about the same. Any increase in the solids of milk is due to an increase in fat or casein, since the variations in the per cents of ash and milk sugar are limited.

All of these points are illustrated in the following samples of milk as given in the table. All of the results are expressed in pounds per hundred of the milk used. The figures in the first column indicate the number of pounds of each compound in the milk. Under the whey column is the pounds of each lost in the whey, and in the green cheese column are the pounds recovered in the green cheese. In the cheese 90 and 120 days old are given the amounts as found by analysis at those dates. The salt used and the cheese bandage is deducted from the weight of the solid matter of the cheese.

In the column headed loss in curing is given the number of pounds of each compound lost in the 120 days of curing. Finally, the percentage composition of the cheese is given.

A more extended series of tables could be given, but a few typical examples are selected. The first is that of average milk, requiring about ten pounds of milk to make one pound of cheese; the second, one of richer milk; the third one testing the same in fats as the second but making a less number of pounds of marketable cheese, and the fourth example one of milk made rich by the addition of cream, while the last one is a good example of skim milk cheese.

Example No. 1.

Milk and Products in Pounds per 100 of Milk Used.

	Milk.....	Whey and Press.....	Green Cheese.....	Cheese 90 Days.....	Cheese 120 Days.....	Loss in Curing.....	Composit'n of Cheese Percentages.....
Water	87.52	80.97	3.65	3.41	3.20	.45	34.29
Solid Matter	12.48	6.23	6.25	6.12	6.05	.20	65.71
Ash	.80	.52	.28				
Fat	3.50	.30	3.20	3.17	3.15	.05	33.76
Casein and Albumen	3.22	.84	2.38	2.30	2.32	.06	24.47
Milk Sugar	4.80	4.35					
Lactic Acid	.15	.22					

Example No. 2.

Water	86.79	80.89	3.59	3.30	3.17	.42	31.3
Solid Matter	13.21	6.11	7.11	6.94	6.86	.25	68.7
Ash	.64	.40	.24				
Fat	4.00	.34	3.66	3.60	3.58	.08	35.3
Casein and Albumen	3.77	.81	2.90	2.84	2.81	.09	27.7
Milk Sugar	4.50	4.30					
Lactic Acid	.15	.26					

Example No. 3.

Water	87.14	81.00	3.85	3.52	3.45	.40	34.84
Solid Matter	12.86	6.25	6.61	6.38	6.29	.22	65.16
Ash	.64	.53	.11	.12	.10		
Fat	4.00	.31	3.69	3.68	3.62	.07	36.56
Casein and Albumen	3.52	.80	2.72	2.68	2.64	.08	25.86
Milk Sugar	4.60	4.35					
Lactic Acid	.10	.24					

Example No. 4.—Creamed Milk.

Water	85.87	76.01	4.56	4.22	4.02	.52	32.42
Solid Matter	14.13	5.69	8.44	8.25	8.19	.25	67.58
Ash	.77	.42	.35	.36	.32		
Fat	6.00	.49	5.51	5.49	5.40	.11	43.55
Casein and Albumen	3.12	.52	2.60	2.50	2.48	.12	20.00
Milk Sugar	4.12	4.00					
Lactic Acid	.12	.26					

Example No. 5.—Skimmed Milk.

				Cured Cheese.		
Water	87.8	80.8	3.00	2.67	.33	30.68
Solid Matter	12 20	6.19	6.01	5.81	.20	69.32
Fat	2.75	.34	2.41	2.36	.05	27.09
Ash	.80	.31	.49	.49		
Casein and Albumen	3.95	.82	3.13	3.86	.07	36.00
Milk Sugar	4.55	4.45				
Lactic Acid	.15	.27				

Losses of Fats in Cheese Making.

SUMMARY OF RESULTS.

No. of Trials.	Fat in Milk.	Average Fat.	Pounds Fat lost Per 100 Pounds Milk.	Per Cent Fat Recovered in Cheese.
28	3.5—4	3.85	.32	91.69
31	4.1—4.4	4.29	.31	92.77
14	4.4—4.9	4.62	.33	92.86
4	5.00	5.05	.28	94.45

The per cent of water and dry matter in the cheese does not depend upon the richness of the milk in fat, for there is a greater difference in the per cent of water in the two cheeses made from 4 per cent milk than between the ones made from milk testing 2.75 and 6 per cent fat. The per cent of water in the cheese depends upon the thoroughness of pressing. The per cent of fat in the skim milk cheese was 27, and the creamed milk cheese 43.5. The cheese made from the 3.5 per cent milk contained 33.76 per cent fat. Comparing the second and the third examples it will be seen that the per cent of fat in the milk was 4 in each case. In example No.2, 7.11 pounds of solid matter was recovered in the green cheese, while in No. 3 there was 6.61 pounds. This difference was due to the fact that in No.2 there was ½ a pound more casein in tne milk than in No. 3. This is partly balanced by the fast that No. 3 contained more water than No. 2. Hence two samples of milk testing the same in fats may not make the same amounts of marketable cheese.

The legal standard for cheese in this state is that 40 per cent of the total solid matter of the cheese shall be butter-fat. In the case of milk skimmed from 3.50 to 2.75, a removal of over 20 per cent of the fat, over 40 per cent of the total solid matter of the cheese was butter-fat. In another case in which the milk was skimmed to 2.80 per cent fat, over 40 per cent of total solid matter in the cheese was butter-fat. In the case of normal milk testing 3:50 per cent fat over 50 per cent of the total solid matter was fat. The fats in full milk cheese should always exceed the casein, since there is always more fat in the milk than casein and albumen, and a larger per cent of the fat recovered in the cheese than of the casein and albumen.

The loss of weight in the curing of cheese is largely a loss of water. The loss of solid matter in curing is about a quarter of a pound for every hundred pounds of milk, whether rich or poor. This includes all mechanical losses. The results indicate that there is a slight loss of casein and fat, in curing, in addition to mechanical losses.

Artificial digestion experiments were made of the nitrogenous compounds. The results are not reported since it was found that the per cent of salt in the cheeses compared was not the same, and the salt that was present in variable quantities re-acted with the acid in the digestive mixture, and introduced an unknown factor. In general it can be said that the casein in well cured cheese from normal milk is nearly all digestible.

In the table headed "Losses of Fats in Cheese Making" it will be seen that the amount of fat lost in every hundred pounds of milk is about .3 of a pound, and is practically the same for both rich and poor milk. The per cent of the total milk fats retained in the cheese made from rich milk is greater than that made from poor milk. All of the additional fat that is in a rich milk goes into the cheese, and whether it pays, financially, to make the extra fat into cheese, depends upon the price that the cheese commands. It must be remembered, however, that a good article cannot be made from poor material.

III.—SUGAR BEETS.

The relation of the Experiment Station to the growing of sugar beets and the introduction of the mannfacture of sugar therefrom is limited to sending out beet seed of known origin each season to intelligent farmers in different sections of the state, there to be grown under known conditions of climate, soil and cultivation, and determining in the beets grown the richness and purity of the juice. The chemical investigations are thus directed towards discovering the adaptability of soil and climate of the different sections of the state to the growth of sugar beets sufficiently rich in sugar to warrant their cultivation for the manufacture of that article. The experiments are repeated in order to determine the influence of variations of seasons on the quantity and quality of the beets. Chemical analysis can do more than give this aid towards answering the question whether beet sugar factories would or would not be successful ventures; the purely financial aspect of the question must be left to other hands.

In addition to the analyses of beets grown from seed sent out by this station, there is reported in this bulletin analyses of beets grown from seed distributed in the counties along the line of the St. Paul & Duluth railroad under the direction of Mr. Hopewell Clarke, the land commissioner of the road. Counties from which such beets were received are Washington, Chisago, Pine and Carlton. Many of the beets from Anoka county were grown under the supervision of Mr. Max Wittges, an expert from the Oxnard beet sugar factories of Grand Island, Neb. The purity of the juice and high per cent of sugar of the beets grown on the sandy loams of this county under wise direction is significant as is the small size of the beets sent for analysis.

In the following tables are given first, the results of the analyses of the beets grown during the season upon the station farm, and afterwards the analyses of the beets grown in the different counties of the state.

SUGAR BEETS RAISED AT THE STATION.

Plot.	NAME OF VARIETY.	Date.	Average Weiight in Ounces of Beets.	Per Cent of Sugar in Juice.	Purity of Juice.
1	French, Very Rich	Sept. 26	8	12.2	80.3
2	Vilmorin Improved	" "	10	13.7	83.
3	Zuckerreichste Elite	" "	11	14.2	84.5
4	Kleiner Elite	" 24	12	14.05	82.3
5	Dippe's Klein Wanzlebener	" "	14	14.6	83.9
6	" " "	" "	12	14.3	84.6
7	Vilmorin White Improved	" "	12	14.6	85.4
8	Dippe's Improved	" "	12	15.5	87.9
9	Knauer's Imperial	" "	12	13.9	82.2
10	Klein Wanzlebener	" "	12	14.4	84.7
11	" "	" 26	9	13.4	82.2
A	" "	" "	12	12.5	80.7
A	" "	" "	12	14.1	84.4
A	" "	" "	18	12.6	80.8
A	" "	" "	12	13.8	83.6
A	" "	" "	11	13.6	85.1
A	" "	" "	15	13.4	88.2
B	Vilmorin Improved	" 28	12	14.4	90.1
B	" "	" "	15	15.3	90.
B	" "	" "	13	15.5	86.5
B	" "	" "	15	14.7	88.
B	" "	" "	20	14.3	87.2
	Average			14.4	84.3
1	French, Very Rich	Oct. 5	14	13.5	83 3
2	Vilmorin Improved	" "	12	14.7	88.4
3	Zuckerreichste Elite	" "	15	14.6	86.4
4	Kleiner Elite	" "	12	13.6	83 4
5	Dippe's Klein Wanzlebener	" "	11	14.7	87.5
6	Vilmorin White Imroved	" "	11	15.6	91.8
7	Dippe's Klein Wanzlebener	" "	10	14.7	87.5
8	" Improved	" "	12	15.3	86.
9	Knauer's Imperial	" 6	10	15.1	86.3
10	Klein Wanzlebener	" "	10	14.4	83.2
11	Vilmorin	" "	14	13.7	84.
A	"	" "	11	14.9	84.2
A	"	" "	13	14.4	85.9
A	"	" 7	13	14.1	84.9
A	"	" "	16	15.	89.6
A	"	" "	14	14.1	90.3
B	Klein Wanzlebener	" 8	16	14.1	84.4
B	" "	" "	12	15.7	86-3
B	" "	" "	22	16.1	87.1
B	" "	" "	16	15.9	84.6
B	" "	" "	16	15.7	86.8
	Average,			14.6	86.
1	French, Very Rich	Oct. 25	13	15.75	86.7
1	"	" "	8	16.8	88.9
2	Vilmorin Improved	" "	16	15.8	85.4
2	"	" "	6	16.9	86.6
3	Zuckerreichste Elite	" "	20	15.5	86.5
3	"	" "	9	17.1	91.
4	Kleiner Elite	" "	14	17.	93.9
4	"	" "	8	17.	95.
5	Dippe's Klein Wanzlebener	" "	16	15.5	91.3
5	"	" "	7	15.9	91.9
6	"	" "	15	16.	95.
6	"	" "	8	16.5	95.
7	Vilmorin White Improved	" "	13	16.2	88.9
7	"	" "	6	16.6	90.
8	Dippe's Improved	" 26	19	16.7	83.8
8	"	" "	8	17.	93.4
9	Knauer's Imperial	" "	18	16.6	86.6
9	"	" "	10	16.8	89.2

SUGAR BEETS RAISED AT THE STATION.

(CONTINUED.)

Plot.	NAME OF VARIETY.	Date.	Average Weight in Ounces of Beets.	Per Cent of Sugar in Juice.	Purity of Juice.
10	Klein Wanzlebener	Oct. 26	12	16.	85.2
10	"	" "	8	15.	86.9
11	Vilmorin	" "	11	14.	84.8
11	"	" "	7	15.	85.7
A	Klein Wanzlebener	" "	8	14.7	85.9
A	"	" "	14	14.9	85.1
A	"	" "	7	14.6	88.
B	Vilmorin Improved	" 27	16	15.	83.9
B	"	" "	10	15.7	86.3
B	"	" "	21	15.4	87.
B	"	" "	16	15.3	86.5
B	"	" "	12	15.7	86.7
	Average,			15.8	88.1

Date of analysis.		Description of Sample.	Total weight in ounces.	Sugar in juice	Purity of juice	No. of plot.	
Oct.	7	4 Beets partly grown above ground	12	11.3	70.4		These samples are not included in the averages.
"	"	1 Beet 18½ inches in length	24	14.5	86.3		
"	8	1 Beet grown half above ground	30	12.6	76.2		
"	"	1 Beet 2 ft. long, 4 in. above ground	32	12.0	75.9		
"	"	5 small b., forked roots, below "	22	13.5	82.3		
"	"	5 " " good form, " "	12	14.2	82.1		
"	"	1 good form beet, medium size	10	18.5	92 3		
"	3	1 coarse large b., part above ground	35	9.1	74.6		
"	29	1 " " ⅓ " "	80	9.1	70.0		
		Average of 73 Samples raised at the Station		14.9	86.3		

ANOKA COUNTY.

Date of Analyses.	Name.	Town.	Kind of Soil.	Date.		Averg. weight of Beets. in Ounces.	Per Cent of Sugar in Juice	Purity of Juice.
				Planted....	Sampled....			
October 22	George Goetze		Sandy loam	May 5	Oct. 19	12	14.1	83.4
" "	M. Claussen		" "	" 15	" "	8	15.4	90.1
" 27	W. Speiser	Centreville	" "	" "	" 24	5	15.1	85.8
" "	D. Capistrant	"	Black loam	" 27	" "	21	15.9	85.5
" "	Mr. LaMotte	"	Sandy loam	" 25	" "	18	13.3	81.
" "	M. Leibel		" "	June 2	" "	17	14.5	90.6
" "	Mr. Blocher	Burns	" "	May 28	" "	17	14.	84.3
" "	Geo. Wyman	Ramsey		" 16	" "	9	16.8	89.8
" "	Andrew Matuska	Blaine	Sandy loam	" 15	" "	13	15.8	86.3
" "	J. W. Kelsey	Ham Lake		" 8	" 19	10	14.8	86.
" "	Mr. Wedworth	Grow		" "	" "	10	13.4	83.2
" "	J. W. Pope	Blaine	Mixed sand and clay	" 5	" "	12	16.3	85.8
" "	A. J. Smith		Sandy loam	" 28	" 22	12	17.3	87.4
" "	W. H. Staples	Grow	Yellow loam	" 15	" "	16	18.1	90.
" "	Mr. Bryer	Oak Grove	Sandy loam	" 28	" "	8	17.2	91.6
" "	E. C. McLoughlin	Ramsey	" "	" 6	" "	11	17.4	91.
" "	Jas. Ridge	"	" "	" 6	" "	11	18.	86.4
" "	Mr. Eddy	"	" "	" 28	" "	7	15.2	83.5
	Average						15.7	87.

CHISAGO COUNTY.

Sept.	27	M. Benson,	Centre City	Clay loam	May 25	Sept.19	12	12.4	76.1
"	29	Geo. Auctr,	Stacy	Sandy "	June 1	Sept.27	21	13.5	85.7
Oct.	1	Aug. Lafgren,	Lent				23	14.1	82.9
"	15	F. Heinrich,	Rush City	Sandy loam	May 18	Oct. 3	24	14.5	82.8
"	"	Ole Bloom,	"	"	June 8	Sept.17	11	13.2	83.9
"	"	L. Clausen,	"	"	May 28	Sept.17	23	12.	75.5
"	"	G. Ramberg,	"	"	June 10	Sept.23	20	13.7	78.2
"	"	Henry Carteer,	"	"	May 29	Sept.19	21	13.5	78.2
"	"	John Wick,	"	"	June 10	Sept.20	21	12.5	78.
"	"	James Hoor,	"	"	June 1	Sept.28	30	14.1	82.
"	"	P. M. Peterson,	Chisago City	Clay loam	May 21	Oct. 18	30	13.8	77.5
"	27	P. J. Anderson,	Rush City	"		Oct. 12	30	13.	80.6
"	"	L. C. Couier,	"	"	June 10		80	11.1	70.
"	"	Jas. Larkin,	"	"	May 20	Oct. 20	28	13.	77.4
"	"	John Johnson,	Harris	"	June 10	Oct. 13	10	16.	82.
Nov.	4	P. X. Peterson,	"	"	May 21	Nov. 2	14	17.3	86.8
"	4	G. W. Hunt,	North Branch				14	18.7	90.
"	23	P. S. Swanson,	"				25	16.0	89.4
"	"	Jno. Berg,	Chisago City	Sandy loam			32	17.7	78.
"	"	Carl Johnson,	"	Black "	May 25	Oct. 18	20	17.1	88.
"	"	Gus. Strand,	"	" "	May 15		26	17.	92.4
"	"	John Ekstrom,	"	" "			8	19.	82.
"	"	Swan Olander,	"	" "			10	18.	82.
"	5	Chas. W. Hanson,	Rush City	" "	May 20	Oct. 15	12	13.6	85.1
		Average,						14·8	83·4

CARLTON COUNTY.

Date of Analyses	Name	Town.	Kind of Soil.	Date. Planted	Date. Sampled	Averg. Weight of Beets in Ounces.	Per Cent of Sugar in Juice.	Purity of Juice.
October 3	S. Lyon	Carlton	Sandy loam	May 18	Sept. 23	16	14.5	83.4
" 9	S. Kebo	Barnum	Clay loam	" "	Oct. 3	16	15.6	86.8
" 9	A. M. Townsend	"	Sandy loam	June 12	Sept. 18	16	14.5	81.5
" 15	Mard Downs	"	"	" 10	Oct. 7	19	13.2	80.
" 15	S. Johnson	Mahtowa				22	13.6	83.9
" 27	Ole Anderson	Thompson				16	13.0	74.3
" 15	J. B. Mayer	Carlton	Sandy loam	May 31	Oct. 6	16	17.	84.6
" 27	C. Rhoel	Moose Lake	Gravel and loam	June 3	" 20	8	17.4	85.4
" 27	J. Mondry		Black and yellow	May 15	Sept. 23	16	14.	84.3
" 27	F Scheforgen		" " "	" 18	" "	9	13.7	80.1
" 15	O. N. Egberg	Mahtowa				23	14.4	80.5
	Average						14.6	82.3

CARVER COUNTY.

Nov. 23.	W. D. Japs	Carver	Clay loam	May 18	Oct. 19	29	13.	82.7
" "	"	"	" "	" "	" "	21	12.6	76.8
							12.8	79.8

DOUGLAS COUNTY.

October 13	F. C. Mead	Alexandria	Sandy loam	May 9	Oct. 4	24	13 1	76.6
" 28	J. G. Winkjer	Garfield	Clay "	June 1	" 11	13	12.	80.
	Average						12.5	78.3

HENNEPIN COUNTY.

October 27	Mr. Bushway	Dayton	Sandy loam	June 8	Oct. 24	13	18.	90.
" "	Jules LaCroix	"	" "	May 15	" "	18	18.	92.
" "	T. Rann	Hassan	Heavy "	May 22	" "	9	17.8	87.5
" "	H. Dalheimer	Dayton	Sandy "	May 15	" "	16	17.4	94.
	Average						17.8	90.8

HUBBARD COUNTY.

Sept. 27	Mrs. Daflenbaugh	Hubbard				26	14.	81.5

KITTSON COUNTY.

Sept. 19	James Gillis	Hallock	Black loam	June 10	Sept. 26	20	12.2	80.

LE SUEUR COUNTY.

Oct. 1	L. B. Donahue,	Le Sueur	Sandy loam	May 25	Oct. 11	25	12.9	78.2
" 15	M. S. Kelly,	"	Black "	May 17	Oct. 11	21	13.1	79.8
" 15	M. S. Kelly,	"	Old Barnyard	June 1	Oct. 11	31	12.2	75.8
" 19	W. Woods,	"	Sandy loam	June 1	Oct. 12	12	13.4	86.5
" 19	J. B. Beer,	"	Garden	June 1	Oct. 12	50	12.5	77.6
" 19	A Hess,	Cardova	Rich Timber loam	June 1	Oct. 14	21	12.3	76.4
" 19	W. A. Patten,	Le Sueur	Rich Timber loam	June 1	Oct. 13	16	13.4	82.2
" 19	"	"	Loam	June 1	Sept. 28	17	12.8	80.
" 27	C. F. Strath,	"	Loam	June 1	Oct. 22	26	13.	77.8
" 27	J. M. Bevens,	"	Sandy loam	June 4	Oct. 21	9	12.9	79.5
Nov. 5	L. W. Toqiooki,	"	Sandy loam	June 1	Oct. 26	51	12.5	84.5
Dec. 3	W. A. Patten,	"		June 10	Nov. 1	32	16.	87.2
" 13	"	"		June 1	Nov. 10	25	13.9	89.
" 17	Wm. Walsh,	"		June 1		29	17.2	80.
" 17	F. Lindeman,	"		June 1	Nov. 1	20	16.3	82.
" 17	S. Bowers,	"		June 1	Nov. 1	16	18.6	84.
" 17	C. Basil,	"		June 1	Nov. 1	36	17.	80.
" 17	B. F. Young,	"		June 1	Nov. 1	14	17.2	81.
	Average,						14.3	81.2

NOTE--These samples were raised under the supervision of Mr. W. A. Patten, secretary of the Le Sueur County Board of Trade.

McLEOD COUNTY.

Date of Analyses	Name	Town.	Kind of Soil.	Variety.	Date. Planted	Date. Sampled	Averg. Weight of Beets in Ounces.	Per Oent of Sugar in Juice.	Purity of Juice.
Dec 21	C. B. Kittridge,	Glencoe	Prairie loam.	Vilmorin	May 10	Oct. 10	17	16.6	83.4
" 21	"	"	"	Klein Wanzlebener	May 10	Oct. 10	19	17.2	84.8
" 21	"	"	"	Vilmorin Improved	May 10	Oct. 10	24	15.5	81.8
" 21	"	"	"	Bultern Richest	May 10	Oct. 10	22	16.7	81.5
" 21	"	"	"	Lane's Improved	May 10	Oct. 10	32	12.2	
	Average,							15.6	82.8

MEEKER COUNTY.

Sept. 18	A. Kopbell,	Watkins				Sept. 9	30	12.5	80.

MOWER COUNTY.

Nov. 23	J. E. Galloway,	Austin		Clay loam	May 25	Nov. 1	25	12.6	83.4

PINE COUNTY.

Oct. 7	A. T. Rice	Pine City	Clay loam	June 1	Sept. 27	36	14.5	82.1
Oct. 8	J. P. Davis	"	"	June 1	Oct. 3	19	17.4	87.0
Oct. 15	A. Asmus	"	"	June 6	Oct. 9	35	14.5	82.
Oct. 22	E. A. Hogan	Hinckley	Clay loam			11	16.5	86.
Nov. 12	A. Sherwood	Rock Creek	"	May 25	Oct. 25	15	14.6	80.7
Nov. 23	John Best	Hinckley				21	14.7	82.1
Nov. 23	John Best	"				31	16.9	80.
Nov. 23	H S. Austin	Pine City	Clay loam	June 15	Oct. 20	20	16.5	80.
	Average,						15.7	82.5

RENVILLE COUNTY.

Nov. 5	H. Prahl	Renville	Black loam	May 24	Oct. 29	16	14.7	83.

RAMSEY COUNTY.

Oct. 5	E. O. Rene	White Bear Lake	Heavy loam	May 27	Sept. 28	16	15.1	86.8
Oct. 15	J. H. McCall	"	Sandy "	May 31	Oct. 7	19	13.5	79.6
Nov. 4	Chas. Morgan	St. Paul				16	17.1	87.6
	Average						15.2	84.7

STEVENS COUNTY.

Nov. 23	Milo Camp	Morris	Prairie loam	May 20	Oct. 10	12	19.2	75.

TODD COUNTY.

	Alex. Kop	Eagle Bend	Yellow Clay	May 20	Oct. 6	42	12.	80.

WASHINGTON COUNTY.

Oct. 27	F. Vieth,	Forest Lake	Sandy loam	May 20	Oct. 6	16	13.7	80.

WRIGHT COUNTY.

Date of Analyses	Name	Town.	Kind of Soil.	Date. Planted	Date. Sampled	Averg. Weight of Beets in Ounces.	Per Cent of Sugar in Juice.	Purity of Juice.
Oct. 27	W. F. Shattuck,	Clearwater	Clay	June 6	Oct. 17	10	14.6	83.9
Nov. 12	J. J. Braot,	Clearwater	Black, Clay Sub-soil	May	Oct. 26	27	14.2	80.
	Average,						14.4	82.

WABASHA COUNTY.

Oct. 25	Geo. Wilson	Lake City	Clay loam	June 2	Oct. 15	18	15.8	87.3
Oct. 25	Geo. Wilson	Lake City	Clay loam	June 2	Oct. 15	22	16.1	87.1
	Average						15.9	87.2

WATONWAN COUNTY.

Nov. 23	Otto Klose	St. James				23	14.8	80.4
Nov. 26	Wiley Paine	St. James				12	14.	80.
	Average						14.4	80.2

PERIOD... ... 30 ...

UNIVERSITY OF MINNESOTA.

Agricultural Experiment Station.

BULLETIN No. 28.

ENTOMOLOGICAL DIVISION.

MARCH, 1893.

THE CLASSIFICATION OF INSECTS AND THEIR RELATION TO AGRICULTURE.

☞ The Bulletins of this Station are mailed free to all residents of the State who make application for them.

ST. ANTHONY PARK, RAMSEY CO.,
MINNESOTA.

EAGLE JOB PRINT, DELANO, MINN.

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Entomology.

There is a constant and rapidly increasing demand from farmers, horticulturists and others more or less directly interested in insects, or more frequently in the ravages and losses caused by them, for a bulletin giving in a condensed form such information as is required to fight our tiny foes in an intelligent manner. Information of this kind in a printed form is of more utility than any number of letters that might be written, since the illustrations necessary to describe clearly any insect can not well be given in a letter.

When we consider the immense numbers of insects that exist in all parts of the habitable globe the task, to give in a few printed pages even an outline of their classification, seems to be a more than futile effort. Moreover, any classification of this multitude of forms (one million species of existing insects is not an exaggerated estimate) must be a more or less artificial one, and it is therefore best to only attempt one of such insects as are known to occur in our own state.

Geologists speak of the age of shells, of fishes, of reptiles, periods all passed long ago, and they might well call the present geological age the age of insects, because these animals outnumber all others combined. In fact insects are found in every part of the globe that man has ever been able to reach, with the exception of the oceans, where they are replaced by closely allied animals, the crustaceans. And yet, notwithstanding the abundance of insects and their almost omnipresence, how few persons are really able to give a definition of an insect? The term *insect* is derived from two latin words *in* and *seco—cut into*, because the body is *insected* or divided into rings. At one time this term was applied to the entire group of articulates or jointed animals, and consequently early writers spoke of "six-legged," "eight-legged,"

"many-legged" insects. Articulates or jointed animals, which by persons not familiar with zoology are frequently called insects are: Wood-lice or Tow-bugs, Mites and Ticks, Spiders, Harvest-men, Book-scorpions, True-scorpions, Centipedes, Thousand-legs and others not found in Minnesota. A glance at the illustrations (Fig, 1 to 6) will show that none of these animals possess the essential characters of true insects as defined below.

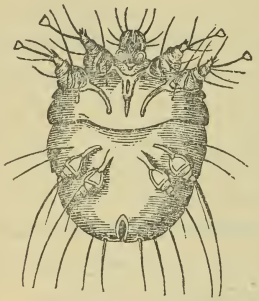

Fig. 1. Female Itch-mite of man, enlarged 80 times.

Fig. 3. Book-scorpion, greatly enlarged.

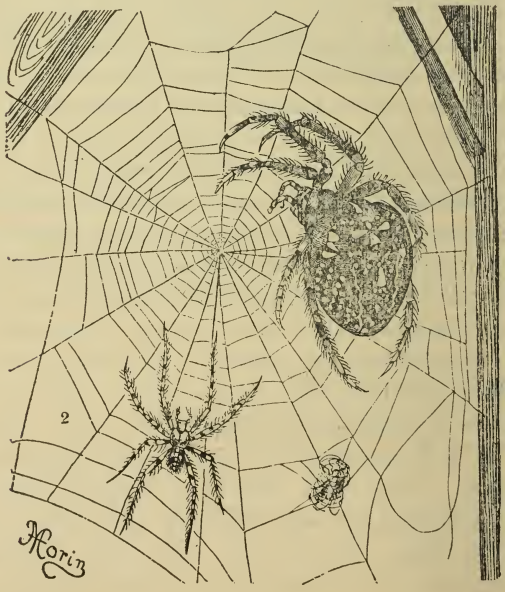

Fig. 2. Male (2) and female of Diadem-spider. Natural size.

Fig. 4. Scorpion. Nat size.

At the present time we use the term INSECT only for those articulates that possess six legs, and that have their external skeleton apparently composed of thirteen joints or rings, which are grouped into three regions, viz: the *head*, *thorax* and *abdomen*. (See Fig. 7.) The true insects, or *hexapoda*, (six-feet) undergo a more or less complete metamorphosis, possess in the adult stage wings, and breathe through a peculiar respiratory system with external openings termed *spiracles*. All insects are developed from eggs, with a few apparent exceptions; plant lice, for instance, reproduce both by eggs and by budding. The body of an adult insect is divided into three regions, each with peculiar functions. The *head* contains the organs of vision (compound eyes and simple eyes), the jointed antennæ or feelers, which are the principal organs of touch, smell and hearing, and the mouth-parts, organs of taste and feeding. The *thorax* contains the organs of locomotion—the three pairs of

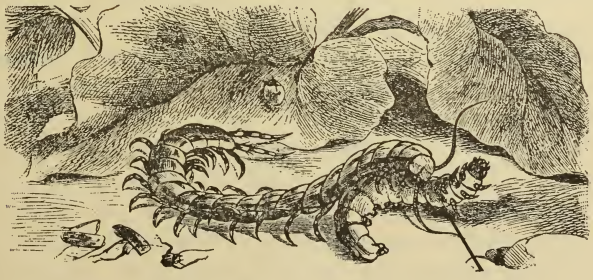

Fig. 5. Centipede. One-half size.

legs and two pairs of wings: The *abdomen* contains the organs of digestion, reproduction and often of defense. All insects pass through a number of transformations or metamorpho-

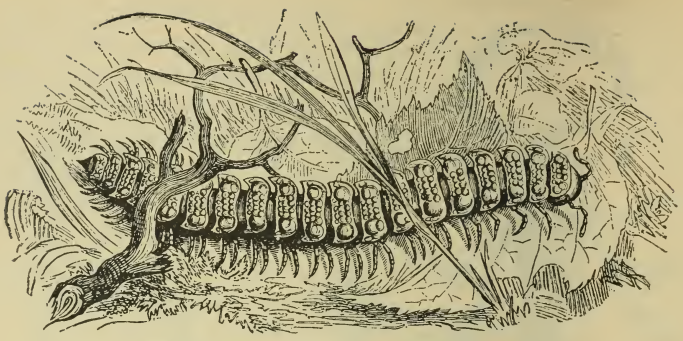

Fig. 6. Thousand-leg. Enlarged.

ses before reaching the adult or winged and sexual stage. The first of the four principal stages is the *egg*. In most cases this is deposited by the female upon the proper food,

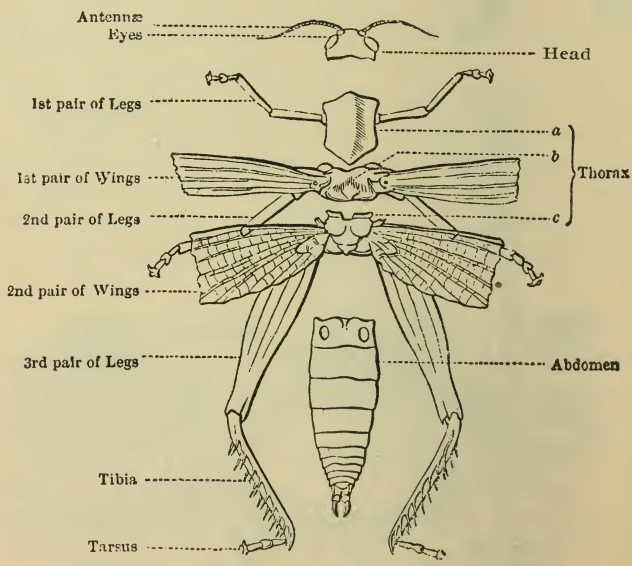

Fig. 7. A Locust or "grasshopper" dissected to show divisions of body.

and is there left to hatch without any further maternal care. In social insects, such as bees, ants, etc., the eggs are taken care of by various methods. In exceptional cases the egg is

retained in the oviduct until ready to hatch, or even until it has hatched. The *larva* (caterpillar, worm, maggot, slug, grub, etc.,) hatches from the egg,and it is in this stage of the life of an insect that most growth is made. But as the external skeleton of an insect does not grow the space within soon becomes too small, and the larva has to throw off this old shell and replace it by a new and more commodious one. This action of throwing off the old shell is called *moulting*, and the process has to be repeated a number of times before the larva reaches its full size. During the larval existence of an insect there is stored up all the material required to produce wings and organs of reproduction, as well as to transform the other organs, as eyes, legs, etc., into their final shape. When fully grown, the larva is transformed into the third stage, or *pupa* (chrysalis, nymph). In this stage the insect is usually quiescent, at least apparently so, though in reality it is a very active stage, as the most wonderful changes have to take place inside the stiff and rigid pupal shell, and freqently within a very short period. After a certain time the skin of the pupa breaks open, and the fourth and final stage or *imago* appears, ready to perform all the functions of a winged, sexual insect. Although these transformations seem to be very sudden, they are really nothing but continuous growth, arrested at intervals by the inflexibility of the outer skeleton. The metamorphoses of insects vary very much, and serve as the basis for separating all insects into two groups, those with a *complete* metamorphosis, as described above, and those with an *incomplete* one. A *complete* metamorphosis is one of the most wonderful transformations known to natural history. From an egg hatches a worm-like creature, always hungry, growing rapidly until its full size is attained, when it suddenly stops feeding, and changing to an apparently lifeless object, becomes a pupa. Remaining almost motionless in this condition it breaks open and gives forth a much larger being, possessing many organs not found before in the earlier stages, and able to fly about to mate and deposit again eggs. In a complete metamorphosis the different stages such as egg, larva, pupa and imago do not resemble each other at all. In an

incomplete metamorphosis we have no such notable changes of form. The egg hatches into a being that looks very much like the parent, being of course quite small, and lacking all traces of wings or sexual organs. This larva feeds just as ravenously, and has in consequence of its rapid growth also to moult a number of times, and during these slight changes in size it acquires gradually rudimentary wings, which increase in size until the adult stage has been reached. But during this whole period of growth no quiescent state like that of a true pupa appears, and the young insect resembles its parent throughout the period of growth. Butterflies are a good illustration of a complete metamorphosis, and locusts of an incomplete.

Illustrations of a complete metamorphosis are given in Fig. 8, 10, 19, 26, 33, 34, 46, 49, 50, 51, 54, 55, 58, 76, 78, and of an incomplete one in Fig. 61, 66, 67, 80.

The mouth-parts of insects give us also an excellent means for classifying them into three groups. One group possesses a *biting* and *sucking* mouth; the second one contains insects which chew their food by means of a pair of horny jaws acting in a horizontal direction; the third group possesses apparently no jaws, and the species belonging here are *sucking* insects. They obtain their food by piercing and sucking by means of four bristles enclosed in a jointed beak, or fluid food by means of a long and flexible tongue.

But why is it at all necessary to classify insects for any practical purpose? In reply it must be stated that we can not fight against injurious insects with any hope of success if we do not know their structure. For instance, an insect that has no mouth to bite or chew can not be poisoned, and the application of any arsenical insecticides would in most cases be perfectly useless. Nor is it enough to know the structure of the insects; we must also know their habits and transformations, because this knowledge alone will enable us to apply the remedies at the proper time. In fact, notwithstanding the great progress made in economic entomology during the last ten years, we are only able to combat successfully a limited number of injurious insects by means of insecticides. A large number of others, and the most injuri-

ous ones at that, can not be reached in that manner. Time, labor and material to do so successfully would cost much more than the whole crop would be worth. The chinch-bug, locusts, cut-worms and others, if very abundant, can not be fought successfully by means of insecticides. Yet this is no reason why we should not be able to reduce their ravages to a minimum. But without being perfectly familiar with the habits of these insects, with their life-history in all and every detail, including their insect and plant foes, we can not hope to succeed. But by knowing all this we may be able to discover a weak spot into which a wedge can be driven to break up their ranks. Only by attacking the weak spot of a well fortified castle is victory possible.

When we consider the immense numbers of insects, and the fact that they devour every and all kinds of organized matter, it seems almost vain even to try to fight against them. All insects are not, however, enemies to man; on the contrary, the great majority are either indifferent to him, or are either directly or indirectly beneficial. The indifferent ones eat substances we can not or do not use; the beneficial ones eat noxious plants, or decaying substances, thus purifying the air and making space for other living organisms. Without them the soil would be covered with dead vegetable matter, the now existing plants, i. e., those that are fertilized by the wind, would become smaller and smaller, because their seeds, not eaten by insects, would all have an opportunity to grow, thus crowding, dwarfing and killing each other. Without insects the great majority of our brightly colored flowers would not produce seeds, as most of them are dependent upon the work of these animals to cause cross-fertilization.

The question is frequently asked: "Why is it that farmers, horticulturists, gardeners, etc., are more troubled in the United States with noxious insects than they are elsewhere?" or "Why is it that more injurious insects and of different kinds are found now than formerly?" The reasons for this increase of insects, both in numbers and kinds, are not so very difficult to give. In Minnesota, when settlements were few and widely scattered, the whole country was covered with

its virginal vegetation. Plants and animals were adapted to each other, and as soon as one of them became for any reasons exceedingly numerous, natural checks in the form of enemies to such plants or animals soon reduced them to their normal numbers. In a state of nature plants distribute themselves in such a manner that one kind never occupies the ground exclusively. Our native forests are not composed of one species of trees, but of very many kinds, in constantly varying proportions which depend upon the character of the soil and the needs of the different kinds of trees. The same is true of the plants that clothe our beautiful prairies. Notwithstanding the uniformity of the soil the prairies are covered here and there with different plants. Animals, and chiefly insects, depending directly or indirectly upon plants, naturally follow their distribution. When the sod of our prairies was broken to receive the seeds of plants not grown there before, the soil responded freely to the new demands and yielded phenomenal crops. This prospective reward for agricultural toil soon attracted more and more farmers until the prairies were teeming with human beings, eager to mine the golden grains—the only form of mining that will make a people really happy and prosperous. But in cultivating more and more soil, man destroyed the finely balanced relation between the animal and vegetable kingdoms by adding a disturbing factor. At first but few destructive insects to the new crops were found, because they had to be introduced from elsewhere; but as soon as they found this Eldorado—an immense area covered with the best kind of food for them—they were not slow to appropriate to themselves what was not planted for them. Insects of all kinds, but at first mainly injurious ones, will invariably take possession of fields where plants of one kind are grown upon a large scale. Insect foes of such plants will soon find their way to such fields and fix there a new home. In course of time, however, things will change for the better, simply because the foes of such newly introduced species will also make their appearance and wage war upon their old enemies. This is one reason why in the older settled parts of the globe insect outbreaks are less frequent, though they

are by no means unknown. The disturbed relationship between plants and animals has there become re-established. Moreover a more diversified farming is the rule in older countries, and insects there do not find such an abundance of food as in regions where their favorite food is grown upon a very large scale.

To enable the reader to recognize his friends and foes amongst insects the following two artificial classifications are given. Both are very simple, and the study of insects, in most cases, requires no magnifying glasses. It is best to compare with both classifications any insect to be located, that no errors be made. Both classifications apply only to the adult or winged insects.

I.

Insects with both a biting and sucking mouth:
  Wings with few veins: *Hymenoptera.*
Insects with a biting mouth:
  Upper wings horny: *Coleoptera.*
  Upper wings like pergament: *Orthoptera.*
  Upper wings with many veins: *Neuroptera.*
Insects with a sucking mouth:
  All wings scaly: *Lepidoptera.*
  Only two wings: *Diptera.*
  Upper wings half leathery and half membranous: *Hemiptera.*

II.

1. With two wings: *Diptera.*
2. With four wings:
   A. Upper and lower similar:
      a. All wings scaly: *Lepidoptera.*
      b. All wings naked or a little hairy:
         1. Wings with numerous veins: *Neuroptera.*
         2. Wings with few veins: *Hymenoptera.*
   B. Upper and lower wings dissimilar:
      a. Mouth-parts forming a sucking tube: *Hemiptera.*
      b. Mouth-parts not forming a sucking tube:
         1. Upper wings horny: *Coleoptera.*
         2. Upper wings like pergament: *Orthoptera.*

INSECTS WITH COMPLETE METAMORPHOSIS.

HYMENOPTERA (membrane-wings.)

This order of insects seems to include the most numerous and perfect forms of insects, such as Bees, Wasps, Ants, Ichneumon-flies, Gall-flies, Saw-flies and Horntails. The order is distinguished by the possession of both a biting and sucking mouth and by having four similar wings with few veins. Most of the insects belonging to it undergo the most complete metamorphosis. Their larvæ are usually unable to search for food and have to be fed by the adults unless it is stored up for them in such a manner that they are surrounded by it. The saw-flies form an exception, however, and they live like the caterpillars of butterflies, in fact frequently resemble them so much as to be called "False caterpillars." Among the members of this order we have many that act very beneficially by fertilizing most of our flowers, by producing honey and wax, and by destroying injurious insects. Others are very destructive and hence are great enemies to farming.

Hymenoptera may be divided into two sections:

1. *Stinging species*, such as Bees, Wasps, Digger-wasps, Ants, etc.

2. *Piercing species*, such as Ichneumon-flies, Gall-flies, Saw-flies, Horn-tails.

1. The stinging hymenoptera are divided into four tribes: *Bees*, *True wasps*, *Wood-wasps*, *Sand and Digger-wasps*.

Bees are classed as *social*, *solitary* and *parasitic*. To the first belong the well-known Honey-bee and Bumble-bee;

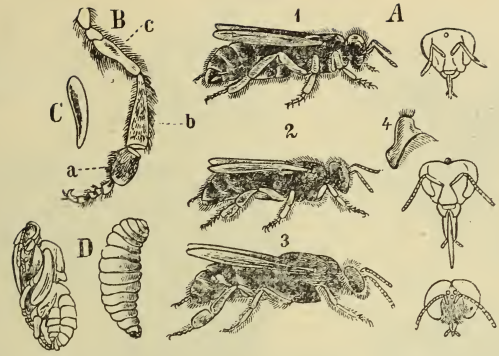

Fig. 8. A. 1, Queen bee; 2, Worker bee. 3, male; heads of same to the right. B, hind leg of worker, showing brush (a) and basket (b). C, egg enlarged. D, larva and pupa.

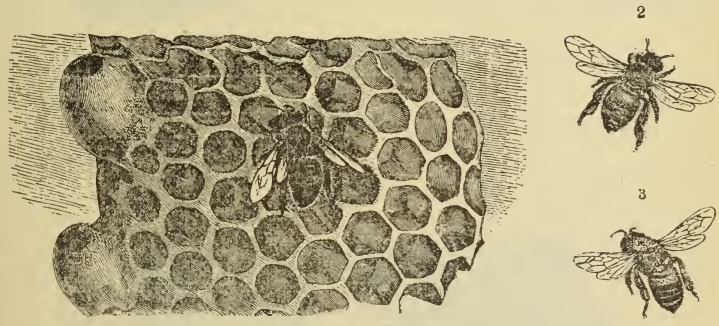

Fig. 9. 1, Honey comb with two queen-cells and German bee; 2, Italian; 3, Egyptian bee.

(Figs. 8 and 9); to the second the Carpenter, the Mason and the Leaf-cutting bees.

The *True wasps* and *Digger-wasps* have also social and solitary species. To the former belong the Paper-wasps, Hornets (Fig. 10, page 86), Yellow Jackets, and other well-known species. The Wood-wasps bore into wood, where they form their cells, and usually fill them with large numbers of plant-lice and other small insects. The Digger-wasps are our largest and brightest colored insects; the Mud-daubers (Fig. 11), Tarantula-killers and others belong here. The Ants (Fig. 12), of which we have a large number of cies, close the section of stinging hymenoptera.

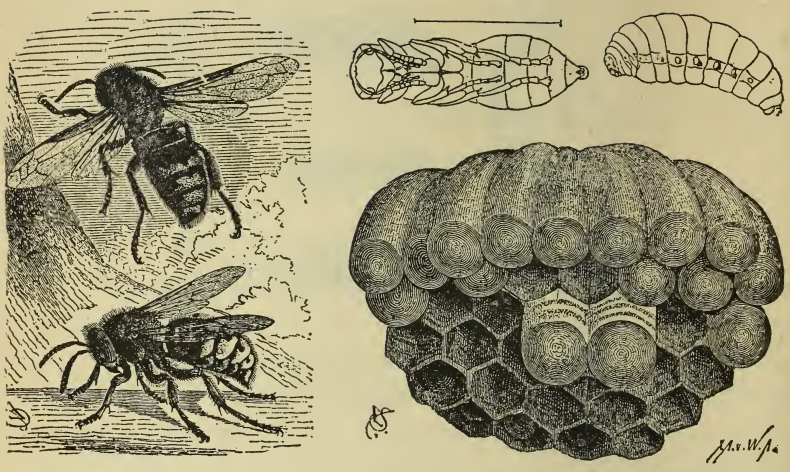

Fig. 10. Hornets, their larva, pupa and cells.

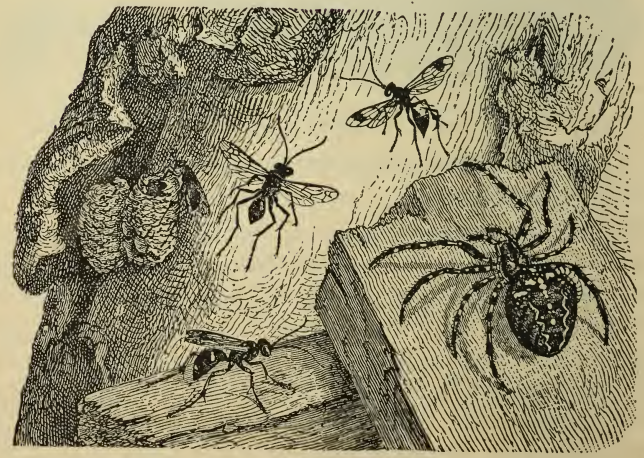

Fig. 11. Mud-dauber, and Pompilus with larva fastened to spider.

Fig. 12. Ant-hill. B, 1, male; 2, female; 3, worker, natural size.

Eig. 13. Parasite (*Ophion*) inserting egg in caterpillar.

2. The piercing species includes two very important groups of insects, the very useful *Insect-eaters*, and the destructive *Plant-eaters*.

Insect-eaters (Figs. 13, 14, 15 and 16) contain several families, best known by the name of Ichneumon-flies and Chalcid-flies. To this series we must add the Gall-flies (Fig. 17 and 18), well known by the peculiar swellings or galls they cause to form upon various plants.

Fig. 14. Parasites. *Ichneumon* above pupa destroyed by it. *Ephialtes* in the act of laying eggs upon wood-boring larva.

Plant-eaters contain such insects as Horn-tails (Fig. 19), and Saw-flies (Figs. 20 and 21). The latter are the parents of the so-called "False Caterpillars" or slugs, so destructive to many species of wild and cultivated plants. The Horn-tails contain but few species, the larvæ of which inhabit the solid wood of trees.

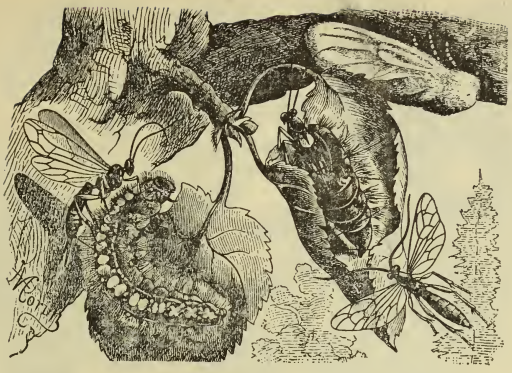

Fig. 15. Parasites. *Pimpla* female laying egg in caterpillar; another issuing from pupa of moth; below it a male, natural size.

Fig. 16. Parasite (*Microgaster*); its larva issuing from caterpillar.

Fig. 18. Rose-gall and Gall-fly.

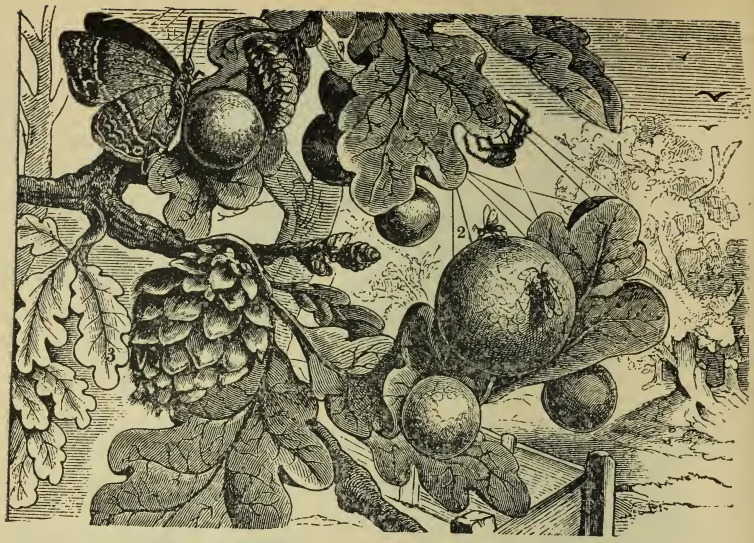

Fig. 17. Oak-galls and Gall-flies (1, 2 and 3).

Fig. 19. Horn-tail, larva, pupa and adult.

Fig. 20. Large Saw-fly, larvæ, cocoon (d) and adult insect, natural size.

Fig. 21. Saw-flies, natural size.

COLEOPTERA (sheath-wings.)

This order is usually considered the largest one, as more than one hundred thousand described beetles are already in our collections. Yet, with the exception of a very few extreme forms, all the species can be readily recognized by their sheath-like upper wings, which meet in a

straight line down the back and cover not alone the abdomen but also the two lower joints of the thorax. These upper wings are not used for flight, but to protect the softer parts below. Only the lower and soft wings, possessing but few veins, and which are usually during rest folded beneath the upper ones, are used for flight. Beetles have a biting mouth and pass through a complete metamorphosis. Many beetles are very injurious, others are indifferent to farming, and still others are decidedly beneficial.

Beetles are divided into two divisions:

1. *True beetles*, with all mouth-parts present.

2. *Snout-beetles*, in which the front part of the head is prolonged into a beak or snout.

1. True beetles are usually divided according to the structure of their feet and their feelers.

Carnivorous beetles, with thread-like antennæ.

Here belong Tiger-beetles (Fig. 22), Ground-beetles (Fig. 23), Carnivorous Water-beetles (Fig. 24), Whirligigs or Apple-smellers. Almost all are beneficial.

Fig. 22. Tiger-beetles, with larva and pupa. Slightly enlarged.

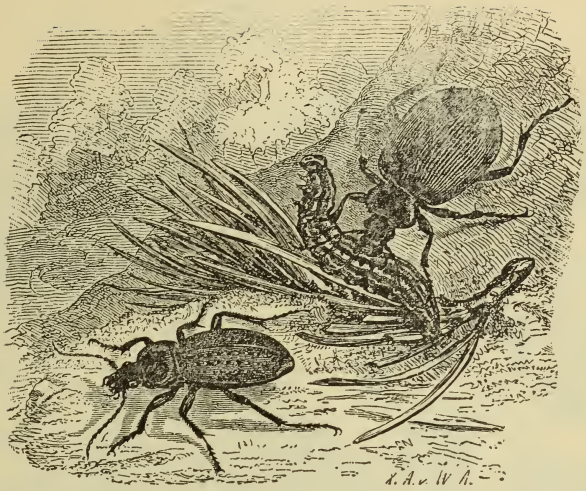

Fig. 23. Ground-beetles.

Fig. 24. Carnivorous Water-beetles.

Club-horns, with club-shaped antennæ.

Here belong Burying-beetles, Rove-beetles, Lady-bugs (Fig. 25), Larder-beetle (Fig. 26), Carpet-beetles and others of various habits. Mostly beneficial, with exception of Larder-beetles and Carpet-beetles.

Fig. 25. Lady-bugs, with larva and pupa. Natural size.

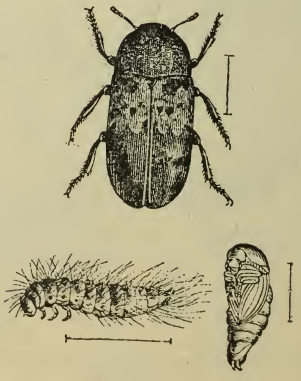

Fig. 26. Larder-beetle, with larva and pupa.

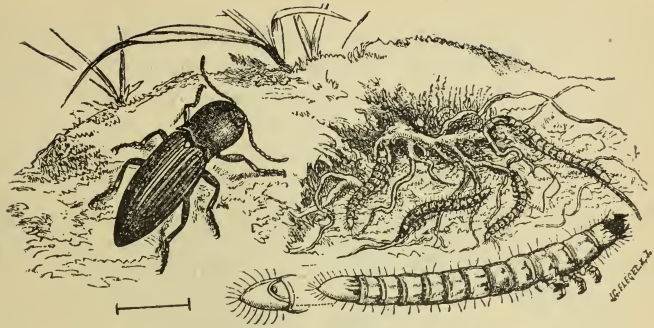

Fig. 27. Snapping-beetle or Wire-worm, with larvæ.

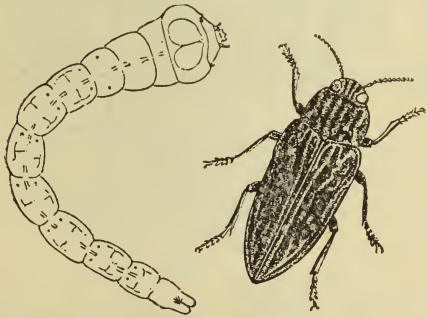

Fig. 28. Large Flat-headed borer of pine. Natural size.

Fig. 29. Fire-flies and their larvæ.

Saw-horns, with toothed or serrated antennæ.

Wire-worms or Snapping-beetles (Fig. 27), Flat-headed borers (Fig. 28), Fire-flies (Fig. 29), Soldier-beetles (Fig. 30), etc., belong here. The first two are mostly injurious; the last two are beneficial.

Fig. 30. Soldier beetles.

Leaf-horns, with knobbed antennæ composed of many leaf-like parts.

Stag-beetes, Tumble-bugs (Fig. 31), Rose-beetles, May-beetles (Fig. 32), June-bugs, Rhinoceros-beetles, etc. All more or less injurious.

Plant-eaters with bead-like antennæ (True Leaf-beetles) or with very long horns (Round-headed Borers).

Among the former we have the smaller forms, as the Potato-beetle (Fig. 33), Poplar Leaf-beetle (Fig. 34), Cucumber beetle, Striped Squash-beetle, Flea-beetles (Fig. 35), and others like the Pea and Bean-weevils. Among the latter we have some very large insects. All beetles belonging here have very long and prominent horns, so that this series of plant-eaters is frequently called Longicorns (Fig. 36). The

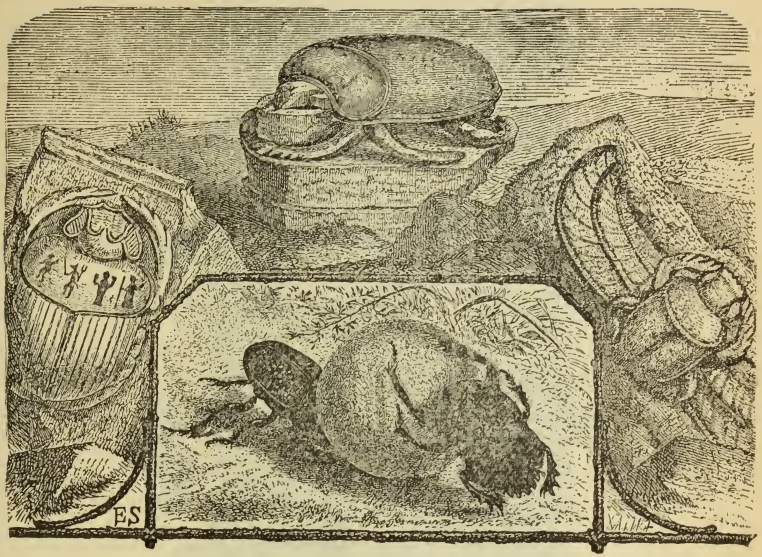

Fig. 31. Tumble-bug. Egyptian sculptures of the Sacred-beetle.

Fig. 33. Potato-beetle in all stages.

common Twig-girdler or Round-headed Apple-tree Borer represent their usual forms. All injurious.

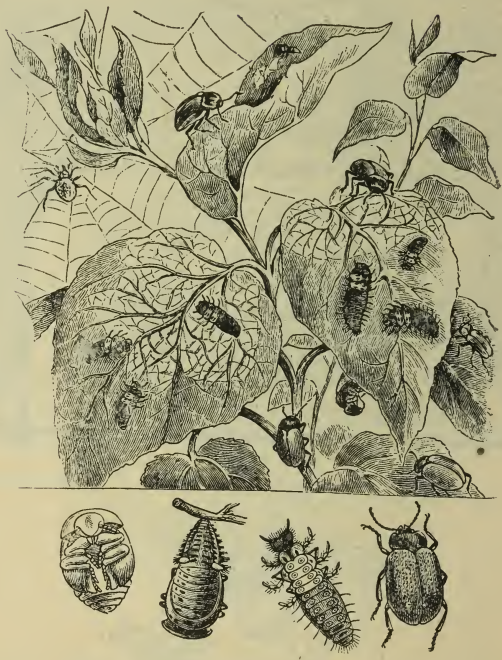

Fig. 34. Poplar Leaf-beetle in all stages.

Fig. 35. Different species of Flea-beetles and their larvæ.

Fig. 32. May-beet'es at night.

Fig. 36. Destructive Longicorn. Their larvæ and work.

To the true beetles belong also the Blister-beetles (Fig. 37), Oil-beetles, Meal-beetles (Fig. 38), and some others, distinguished from the species mentioned before by having an unequal number of joints in their feet. Injurious and beneficial forms.

Fig. 37. Blister-beetles. With first larva.

2. Among the Snout-beetles we have insects like the Plum and Apple-curculios, Nut-weevils (Fig. 39), Rice and Corn-weevils, Bill-bugs, Plum-gouger and Bark-beetles (Fig. 40). All are injurious if infesting cultivated or useful plants.

Fig. 39. Nut-weevil.

Fig. 38. Meal-beetle.

Fig. 40. Work of Bark-beetles.

LEPIDOPTERA (scale-wings).

Fig. 41. Currant-butterfly. Natural size.

Butterflies and moths are best known to the casual observer, the former being frequently so brightly colored as to be called "winged flowers." This order of insects is distinguished by having both sides of their wings covered with many-colored scales, arranged in definite patterns, like shingles upon a roof. Insects belonging here have in their perfect or winged stage the mouth-parts united in a long tongue coiled up like a watch spring. They under-

go a perfect metamorphosis, and in their larval stage they are well known as caterpillars. In this stage they belong most decidedly to the biting insects, as it is in this stage that a large number of them become very destructive. With very few exceptions caterpillars feed upon leaves, fruit and wood, while many of the moths themselves eat nothing, or honey and other fluids.

Lepidoptera are usually divided into two divisions:

1. *Butterflies*, with club-horns.

2. *Moths*, with variable horns.

1. The butterflies are day flyers, and have stiff antennæ ending in a knob or club. Examples are the Parsley Swallow-tail, the White Cabbage-butterfly and Currant-butterfly (Fig. 41.)

2. The moths are divided into many families, such as Sphinx-moths, Clear-winged moths, Spinners, Owlet or Cut-worm moths, Span-worms or Measuring-worms, Snout-moths, Leaf-rollers, Tineids and Plume-moths.

Fig. 42. Pine-sphinx. With eggs, young and old caterpillars.

Sphinx-moths are large and bulky insects which fly at dusk, and produce large caterpillars possessing usually a pointed horn on tail. The Ash-tree-sphinx and Pine-sphinx (Fig. 42), are examples of this family. Clear-winged moths are small and resemble more or less closely some wasp or fly.

Fig. 43. Glassy-winged Oak-borer and empty pupal skin.

Fig. 44. Large Bear, with larva. Natural size.

Their larvæ are all very injurious borers, as for instance the Oak-borer (Fig. 43), and the Currant-borer. Spinners are bright-colored, medium-sized moths (Fig. 44), though some of our largest insects belong to this family, for instance our common native Silk-moths. Most of their caterpillars spin

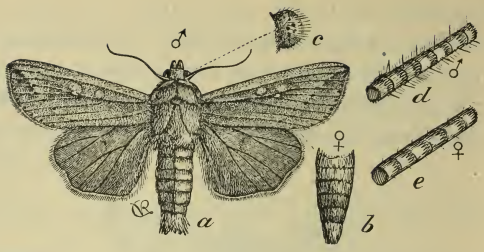

Fig. 45. Army-Worm. Caterpillar, pupa and adult.

Fig. 46. Geometer, with caterpillars and pupa.

silken cocoons, inside of which they transform to pupæ, as is the case with our destructive Tent-caterpillars. Owlet-moths or Cut-worm moths are night-flying, medium-sized insects, usually of very plain colors, though remarkable exceptions occur. Their caterpillars are more or less injurious, depending upon the value of the food they consume. The Army-worm (Fig. 45 and 45½), Lesser Army-worm, Onion Cut-worm, Corn-worm are familiar examples. Span-worm moths are slender insects, with large and weak soft-colored wings.

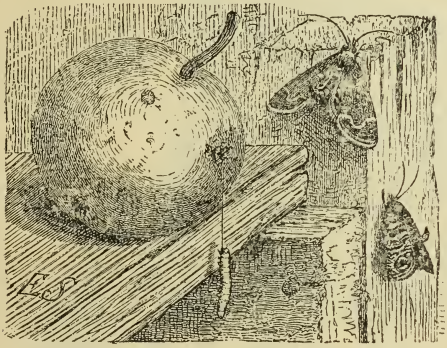

Fig. 47. Apple-worm and moth. Above Flour-moth.

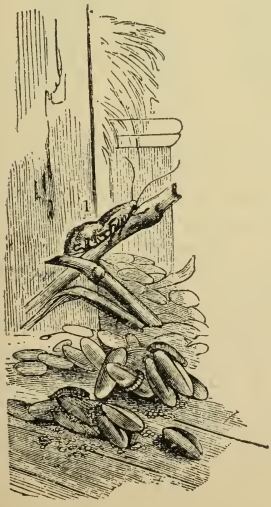

Fig. 48. Grain-moth.

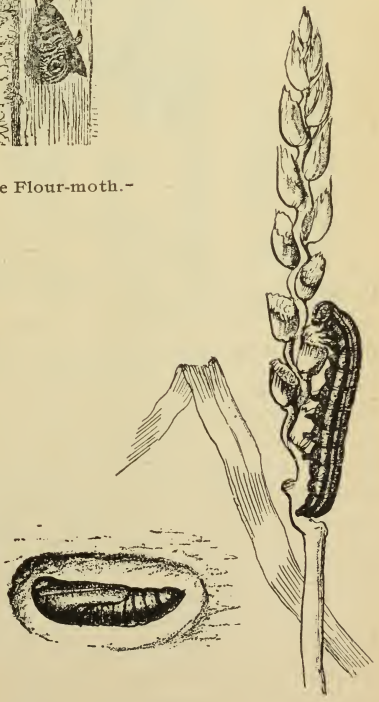

Fig. 45½. Army-worm, larva eating ear of wheat, and pupa.

They produce the peculiar "measuring worms" "or loopers" (Fig. 46), that frequently resemble very closely some dead twig. Some species, like the Canker-worms, have wingless females. The other families of lepidoptera are all small with various habits. Grass-worms, the Codling-moth, Flour-moth (Fig. 47), Grain-moth (Fig. 48) and Bee-moth (Fig. 49), Grape-vine Plume and allied forms are familiar examples.

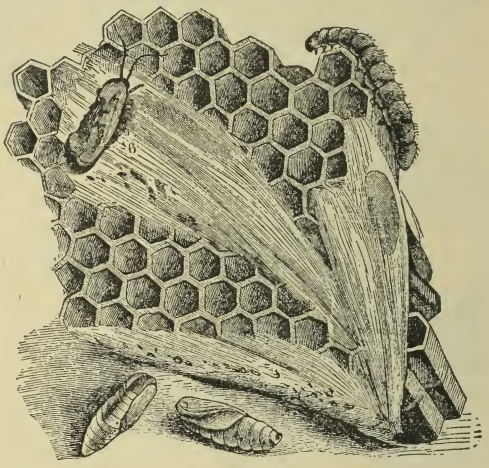

Fig. 49. Bee-moth. All stages.

DIPTERA (two-wings.)

All the members of this order, such as House-flies, Blow-flies, Bot-flies, Mosquitoes, Gnats, etc., are at once distinguished from all other insects by having only one pair of wings. The hind wings are rudimentary, usually thread-like, each ending in a little knob, which are called *halteres* or *poisers*. All flies are soft and usually rather small. The structure of their mouths varies greatly, but all are equipped for sucking fluids. Several species of flies can inflict painful injuries as their jaws are modified in such a way as to act like sharp lancets strong enough to pierce even the tough skins of large animals. The antennæ of flies are either very short, or long and sometimes feather-like. The metamorphosis of all flies is complete, yet there is a great difference among their pupæ, which are either enclosed in the hardened larval skin or resemble the free pupæ of Hymenoptera and Coleoptera. In some cases, as in the

Mosquito, the pupa is active, but does not consume any food. The larvæ of flies are generally called maggots.

Diptera are usually divided into two divisions:

1. Species in which the free pupa leaves the larval skin through a slit between the seventh and eighth joints.

2. Species in which the pupa is enclosed in the larval skin, from which the perfect insect escapes through a circular hole on top of the *puparium.*

To the first division belong flies like the Gall-gnats, Hessian-fly (Fig. 50), Wheat-midge, Buffalo-gnats, Mosquitos (Fig. 51), Crane-flies, Gad-flies (Fig. 52), Robber-flies, Bee-flies and parasitic Anthrax-flies (Fig. 53.)

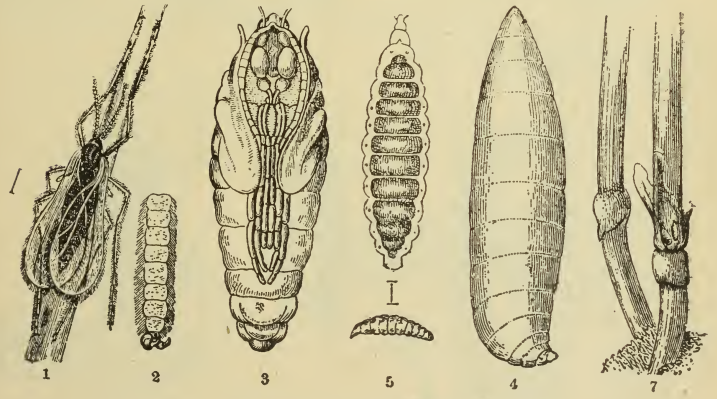

Fig. 50. Hessian Fly. 1, Adult female; 2, Male abdomen; 3, Pupa removed from "Flax-seed"; 4, 5, Larva; 7, "Flax-seed" in position.

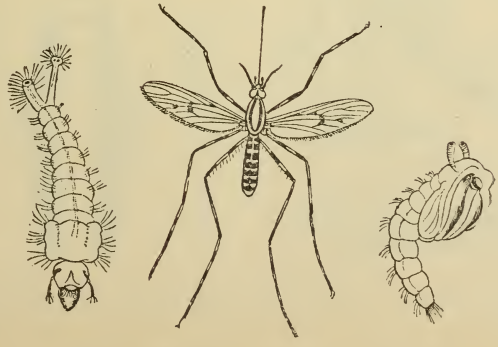

Fig. 51. Mosquito. With larva and pupa.

Fig. 52. Gad-fly or Horse-fly.

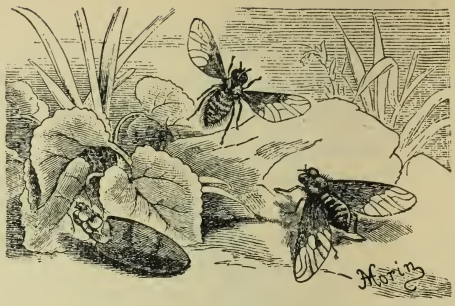

Fig. 53. Parasitic Anthrax-fly.

To the second division belong flies like the Syrphus-flies (Fig. 54), Bot-flies (Fig. 55), Tachina-flies, House and Flesh-flies (Fig. 56), Cheese-flies and Frit-flies (Fig. 57.)

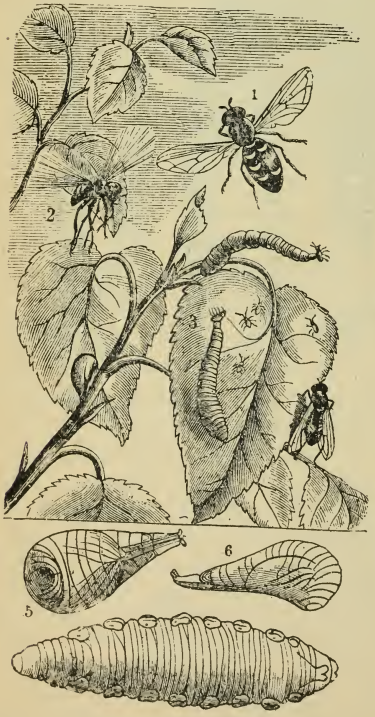

Fig. 54. Syrphus-flies. 1 and 2, adults; 3, larva eating lice; 4, contracted larva; 5 and 6, pupa.

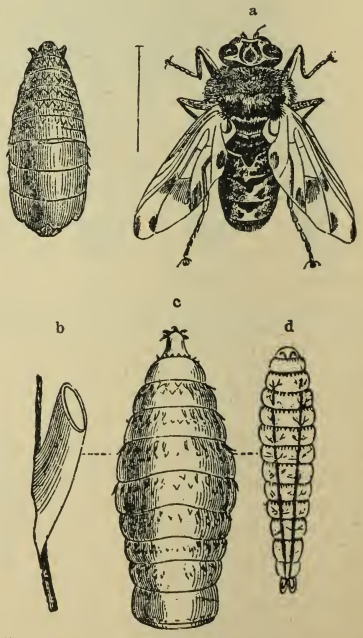

Fig. 55. Bot-fly. a, adult; b, egg; c, mature larva; d, young larva; e, puparium.

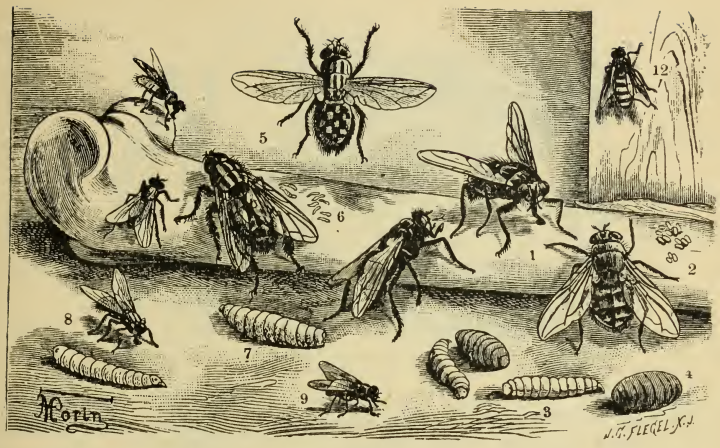

Fig. 56. Flesh and House-flies, with their eggs, larvæ and pupæ. 12, House-fly killed by fungus.

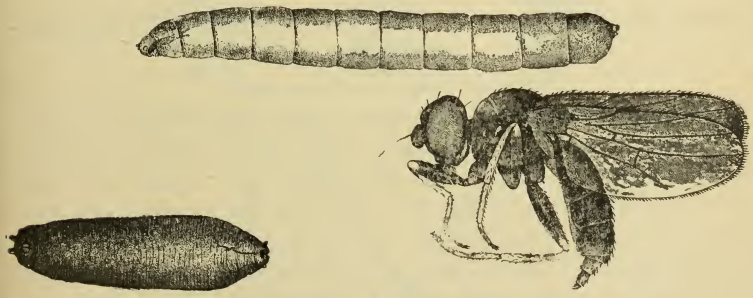

Fig. 57. Frit-fly. Larva, pupa and adult.

As a general rule all flies are considered very injurious insects, but there are many very pleasing exceptions. Tachina-flies, for instance, are our best friends, checking the undue increase of noxious insects. Without Syrphus-flies the Leaf-lice would soon destroy all vegetation. Even the troublesome House-fly must be called beneficial, since it performs the functions of a public health-officer, and performs it well. Without it the smaller particles of decaying animal and vegetal matter would soon fill the air near our houses with fatal odors.

Among the flies of lower organization may be counted the Fleas (Fig. 58), which in their early stages possess the

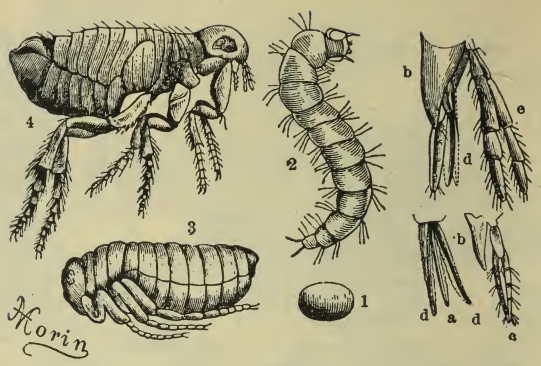

Fig. 58. Common Flea. 1, egg; 2, larva; 3, pupa; 4, adult Flea; *a-e*, mouth-parts.

characters of the order. The peculiar Sheep-tick and Horse-tick are also degraded flies—degraded in form as a result of leading a parasitic life.

INSECTS WITH AN INCOMPLETE METAMORPHOSIS.

HEMIPTERA (half-wings).

Insects belonging to this order are *bugs*, a term that should not be applied to any other order of insects. Many members of this order possess wings which are half-membranous and half-leathery, whence the compound Greek term *hemi-ptera*—half-wings. All obtain their food by sucking the juice of living plants or animals. To enable them to do so the mouth is composed of a three or four-jointed beak, in which are snugly hidden two pairs of fine bristles well adapted to pierce and to suck. The metamorphosis of bugs is incomplete, and their pupæ are as active and feed as well as the larvæ or the adults. We may arrange all hemiptera into three groups:

1, *True Bugs* (*Heteroptera*).
2. *Harvest-flies*, *Leaf-hoppers*, *Plant-lice* (*Homoptera.*)
3. *Lice.*

The True Bugs are the only ones that are distinguished by half-wings, and to which the definition of bugs given above applies in every particular. They are *terrestrial*, *amphibious* or *aquatic* in their habits. The terrestrial bugs are either *plant-feeders* or *cannibals*. The former (Fig. 59 and Fig. 60—1 and 2), mostly very injurious insects, have a more slender beak than the latter. Familiar examples are the

Fig. 59. Plant-feeding Heteroptera (*Calocoris.*)

Fig. 60. Plant-feeding Heteroptera: 1, *Tingis;* 2, *Aradus.* Cannibal Heteroptera: 3, Bed-bug.

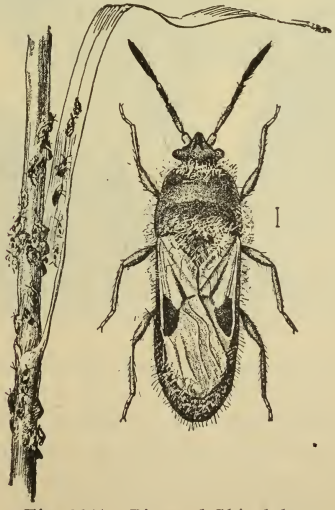

Fig. 60½. Diseased Chinch-bug.

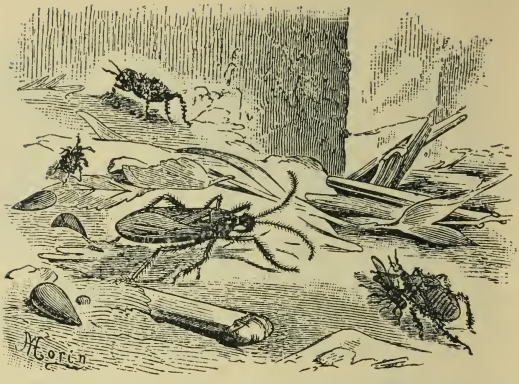

Fig. 61. Blood-Sucker (*Reduvius*) with active larvæ and pupæ.

Fig. 62. Harvest-flies: 1, *Cicada orni*, common in Manna in drug stores; 2, Singing Cicada, with pupa.

Squash-bug, Chinch-bug (Fig. 60½), Tarnished Plant-bug, Four-lined Leaf-bug, Negro-bug. Among the cannibal bugs with shorter and stouter beaks we have many friends, but also some dreaded foes. Insects like the Soldier-bug, Blood-sucker (Fig. 61) and Bed-bug (Fig. 60-3)belong here.

Among the amphibious bugs the best known are those that run like spiders over the surface of water in pools and ponds. The Giant water-bug or the Electric Light-bug, the Water-scorpion and the Boat-man are familiar forms of aquatic bugs.

2. The second group of bugs, the *Homoptera*, are distinguished by having their wings of the same texture throughout. This group is divided into many families, all of which are vegetable feeders. Familiar examples of the families are the Harvest or Dog-day flies (Fig. 62), insects distinguished from most others by the possession of a sound-producing organ, to which belongs the famed Seventeen-year Cicada or Locust; the Tree-hoppers, as the Buffalo Tree-hopper; the Leaf-hoppers, as the Grape-vine Leaf-hopper and the Spittle-insect (Fig. 63). The Plant-lice (Fig. 63½) also belong

Fig. 63. Spittle-insect. With "Cuckoo spittle" produced by larvæ and pupæ.

here, many of which are exceedingly injurious. As already mentioned these insects reproduce in two ways—by laying eggs and by producing living offsprings. The Bark-lice or Scale-insects are also members of this group. Although generally very injurious some form a notable exception, as the Cochineal insect (Fig. 64), that produces the beautiful crimson color; others produce wax and lac.

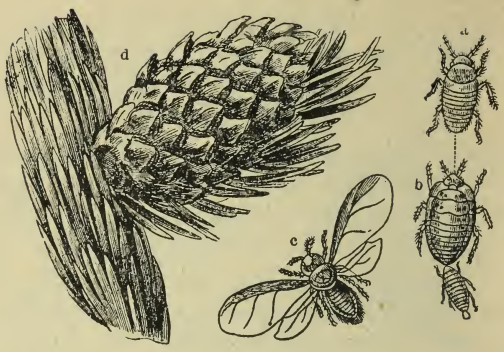

Fig. 63½. Pine-louse; *a*, young louse; *b*, female producing young; *c*, winged louse; *d*, gall produced by lice.

Fig. 64. Cochineal insect.

3. Lice (Fig. 65) are also members of the order of hemiptera, and members not in good standing. They are all small, wingless, and are parasitic upon mammals, including man. Bird-lice, though very similar to true lice, do not belong here, as they possess a biting, not a sucking mouth.

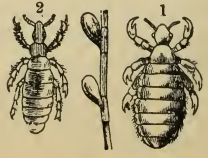

Fig. 65. 1, Head-louse with eggs; 2, Body-louse.

ORTHOPTERA (straight-wings).

Grasshoppers, locusts, katydids, crickets, walking-sticks, roaches and others are members of this order. All are fairly large, possess a biting mouth and pass through an incomplete metamorphosis. Some of the most injurious insects belong to this order, such as the Migratory locusts, too well known in Minnesota.

We can divide this order into four groups according to the structure of their legs and their mode of locomotion:

Jumpers, Walkers, Graspers and *Runners.*

1. Among the *jumpers* we place such insects as locusts, grasshoppers and crickets. Locusts (Fig. 66 and 67), fre-

Fig. 66. Migratory Locust described in the Bible.

quently misnamed grasshoppers, are very familiar insects which devour all sorts of grass or grains and other low plants. As a general rule they are of a dingy color so as to resemble the ground upon which they live, though a few have bright-colored underwings. These are, however, only displayed when the insect is on the wing and then only for a very short time, since the common locusts do not readily fly except when disturbed or during their mating season. A few

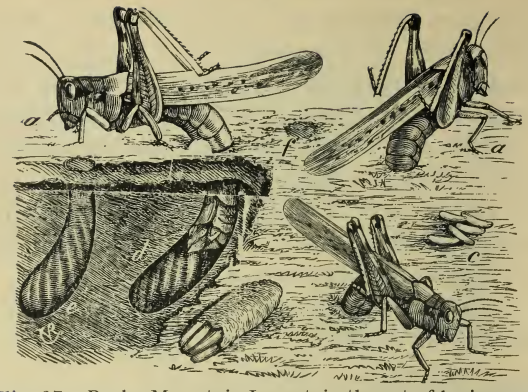

Fig. 67. Rocky-Mountain Locust, in the act of laying eggs.

are social and migrate together in such numbers as to resemble clouds (Fig. 68). Their eggs are deposited in the ground in bean-shaped masses. The males of most jumpers produce a loud sound by fiddling, or by rubbing the inner surface of the hind thighs over the mid-rib of the upper wings.

Among the *grasshoppers* we have such familiar insects as the Katydids, Cone-heads and Sword-bearers. Most of them are bright green, more or less arboreal, and produce their love songs by rubbing or grating together the base of their upper wings, which are modified for this purpose. The eggs of these insects are usually inserted into the pith of plants or glued upon the surface of twigs.

Crickets, also members of the jumping orthoptera, can be separated into three groups, viz: Tree-crickets, Field-crickets and Mole-crickets. Among the first group we have the injurious Snowy-cricket; among the second the big-headed black Field-crickets (Fig. 69½), which are a very familiar sight near stone walls. The Mole-cricket (Fig. 69) is not often seen, as it seldom leaves its peculiar burrow under ground, and if so only at night. Not on account of its burrowing habits alone has this insect received the name of Mole-cricket, but also because its first pair of legs are transformed into digging implements like those of a mole. Though all crickets are more or less injurious they are not without their redeeming characters, since they eat large numbers of injurious insects.

Fig. 68. A Swarm of Locusts.

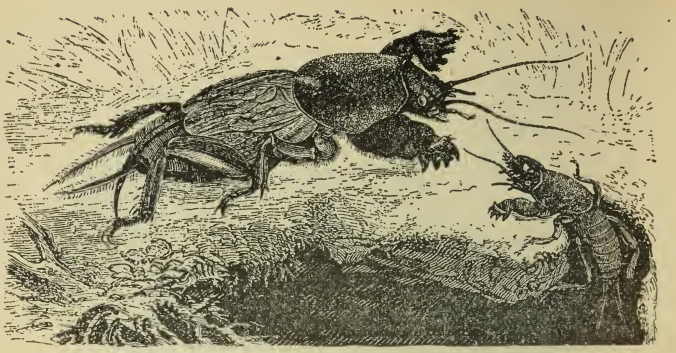

Fig. 69. Mole-cricket.

They also produce a sound in a manner similar to the grasshoppers.

It should be mentioned here that the sounds produced by insects are made only by the males to call the females.

Fig. 69½. Field-cricket. 1 and 2, adults; 4, active pupa. Below 1 crickets just hatched.

2. *Walkers.* "Walking-sticks," "Walking-leaves," etc. are very peculiar insects, and well deserve the above names. We have but one species in Minnesota, which looks—when at rest—exactly like a dry twig (Fig. 70). When moving it seems to be suffering from some acute pains in the joints. Every external organ of these insects is drawn out as long as possible, which may account for the apparent pains. The insect feeds upon all kinds of foliage, and is sometimes de-

structive to our hazelnuts. It drops its peculiar eggs singly and is not in the mood to produce love songs.

3. *Graspers*, or "Devil's Riding Horses," "Camel-crickets" (Fig. 71), "Rear Horses," etc., do not occur in our state. They

Fig. 70. European Walking-stick with larvæ.

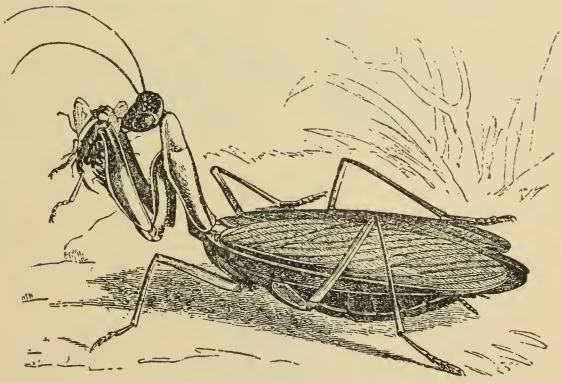

Fig. 71. Preying Mantis.

are quite common farther south, and are distinguished by their spiny front legs, well adapted to grasp their food, which consists of all kinds of insects. Their position during an apparent rest is that of praying, but woe to the poor unsuspecting victim that may come too near, as it will soon discover the fact that in this case praying is spelt preying.

4. *Runners* are represented by such insects as Cock-

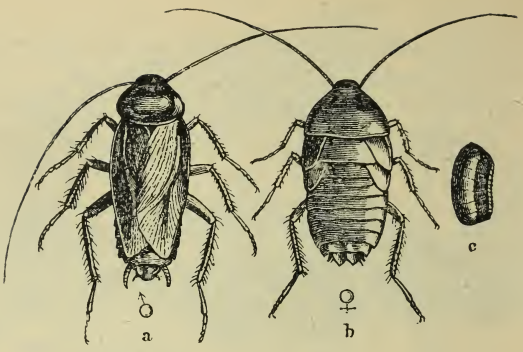

Fig. 72. Cockroaches: *a*, winged male; *b*, unwinged female, *c*, egg-mass.

roaches (Fig. 72), some of which are household pests, though the great majority of these disgusting insects live under loose bark of trees. They are all nocturnal iu their habits and excel in the rapidity of their movements. Such injurious insects as the Croton-bug are familiar examples of these running orthoptera. They deposit their eggs in one yellowish-brown bean-shaped mass, which is frequently carried about for some time before being dropped into some crack or crevice.

The *Ear-wigs* also, a small group of insects distinguished by a formidable looking pair of forceps at their posterior end, belong to the orthoptera, and are illustrated in Fig. 73.

Fig. 73. Ear-wig.

The peculiar group of insects termed *Thrips* (Fig. 74) and the unwinged *Spring-tails* may also be arranged with the orthoptera. The former are more or less injurious, and

occur frequently in vast numbers in the heads of wheat and clover. Spring-tails well deserve their popular name on account of their mode of locomotion. The so-called Snow-fleas (Fig. 75), which sometimes blacken the surface of the snow by their presence, are well known examples. The biting lice infesting animals, and chiefly birds, may also find a place at the end of orthoptera.

Fig. 74. Thrips, the dots upon wheat-plant showing natural size.

Fig. 75. Snow-fleas.

INSECTS WITH A COMPLETE OR AN INCOMPLETE METAMORPHOSIS.

NEUROPTERA (nerve-wings).

This is an order of insects that is now separated into many smaller ones, and for very good reasons; but as only a very few of the insects that form this assemblage are of any economic importance it is best to retain them all in this one order. All the insects that belong to it are distinguished by possessing wings with many veins and all have a biting mouth. The metamorphosis of the various families is quite different, in some cases it being a complete and in others an incomplete one. We divide them most naturally into two sections:

1. *With a complete metamorphosis* (*Neuroptera*).
2. *With an incomplete metamorphosis* (*Pseudo-neuroptera.*)

To the first section belong such insects as the Caddice-flies, Ant-lions, Lace-wings, Hellgrammite-flies and others.

In the sesond one we place Dragon-flies, May-flies, Stone-flies and White Ants. Some unwinged insects, as Book-lice may also find here a place.

Caddice-flies are aquatic in their early stages and feed upon small water animals. The larva always protects itself by a little house made of silk and covered in a more or less regular manner with all sorts of material found at hand. The mature insects look somewhat like moths denuded of scales (Fig. 76).

Ant-lions (Fig. 77) may possibly be found in Minnesota, but none have as yet been recorded. The adult insects have large lace-like wings and antennæ. Their larvæ dig peculiar pits in sandy soil and devour insects that fall into these traps.

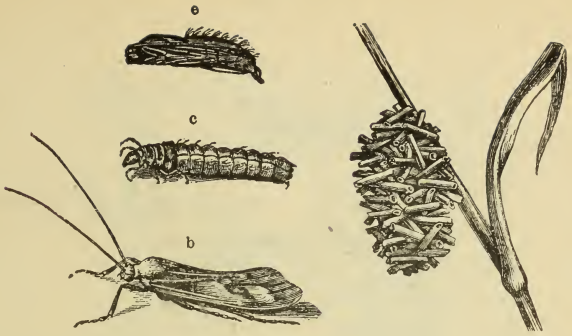

Fig. 76. Caddice-fly: *a*, house made of stems; *b*, adult; *c*, larva removed from house; *e*, pupa.

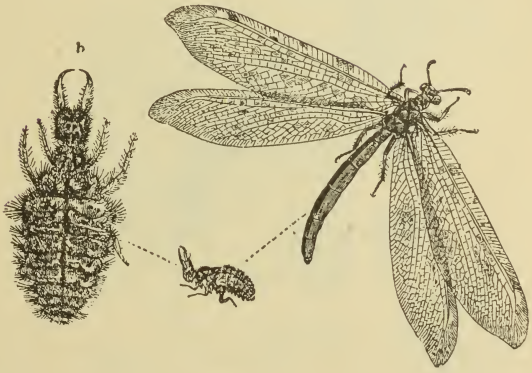

Fig. 77. Ant-lion, with larvæ, enlarged and natural size.

Lace-wings or Aphis-lions (Fig. 78) are very beneficial insects of small size. The mature and winged insects are usually green or pale red, and possess unusually prominent eyes of a golden color. The larvæ are flat, with very large jaws, and are almost constantly engaged in devouring their usual food, the plant-lice. Their round and white silken cocoon is very small in comparison with the large imago that issues from it through a circular lid. The eggs are fastened singly to a slender silken stalk, of which many are fastened side by side.

Hellgrammite-flies are large insects with a very forbidding aspect. The larva is aquatic and carnivorous. To them belong the dark colored and much smaller insects that

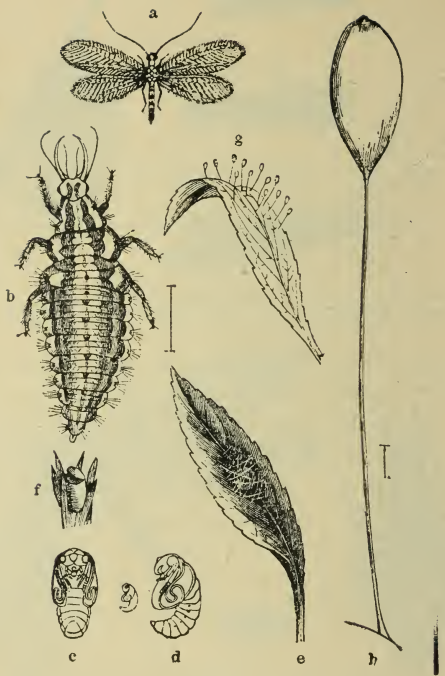

Fig. 78. Lace-wings: *a*, adult, natural size; *b*, larva, greatly enlarged; *c* and *d*, pupa; *f*, cocoon; *g*, eggs; *h*, egg, greatly enlarged.

are sometimes so numerous about the shores of our lakes (Fig. 79).

To the second section belong a number of our friends, such as the *Dragon-flies* or *Mosquito-hawks* (Fig. 80).

These active insects, almost constantly upon their wings during fine weather, possess four large wings of rather uniform size, frequently ornamented with bright spots and metallic colors. Their food consists of all sorts of adult insects, the smaller ones of which they eat without interrupting their flight. Immense numbers of mosquitos and gnats are destroyed by them, and as both mosquito-hawks and mosquitos are raised in the same pool of water the former never lack sufficient material for their enormous appetites. But as the pupa is as active in the water as the larva, constantly waging war upon other insects, they are really very beneficial in all three stages. In the early stages these dragon-

Fig. 79. Sialis: 1, eggs; 2; larvæ; 3, pupa; 4, adult flying, and depositing eggs.

flies posess a sort of mask, the anterior edge of which is provided with two sharp hooks. This whole mask can be greatly extended so as to reach a victim at a distance and carry it to the true jaws for mastication.

May-flies or "One-day flies" (Fig. 81) are exceedingly abundant upon some of our lakes, flying often in clouds over the shores and soon covering them with their dead bodies, which in some countries are gathered by the farmers as fertilizers. Lacking mouth-organs the few hours of winged existence are simply utilized by the insects to mate and to deposit their eggs. Their larvæ, which are aquatic, grow but slowly and have to pass many moults before reaching the adult stage.

Fig. 80. Dragon-fly, with active pupa and empty pupal skin.

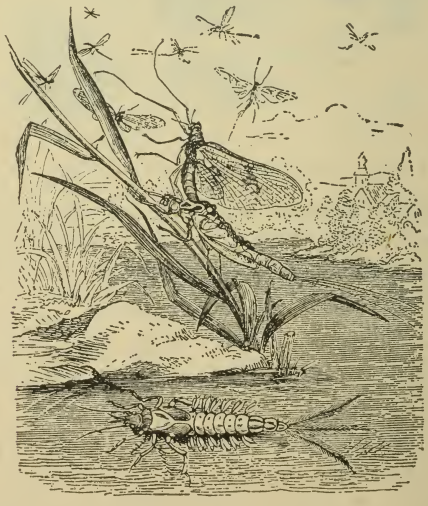

Fig. 81. May-fly (*Ephemera*) leaving shell, and active pupa

White-ants are not found in Minnesota; they are a feature of southern regions where they form large colonies like our true ants, in which we find, besides the males and females, workers and soldiers also. All white ants feed upon dead wood and are therefore useful scavengers in a state of nature.

ENTOMOLOGY, or the science of insects, is divided into several distinct branches. Some students devote their time to describing and classifying insects, and consider mainly their structures, not their habits or life-histories. Of course structure indicates to some extent habit. This strictly *scientific entomology* is very important, since without it entomology would simply be chaos. But scientific entomology is of very little use to the tiller of the soil, as it gives him only the scientific names of his enemies but not the means to protect himself against their depredations.

Economic, applied or practical entomology does not discard scientific entomology, without which it could not exist, but it centers its attention upon the habits of insects, so as to become enabled to devise the proper means either to combat or to protect them. Again there are persons who simply collect insects for the sake of having fine and complete collections. If this was their only aim they might as well simply gather a complete collection of old shoes, so far as their aid to entomology is concerned. But happily there are few of such collectors who simply collect bright insects and arrange them, perhaps, in a more or less spread-eagle style, or form out of bright colored carion-beetles the initials of a dearly beloved one. As a very general rule they discover many new species and permit the scientific entomologist to make good use of their diligence by giving him free access to their treasures.

Economic entomology is a very important science and becomes so more and more with increased knowlege. Prof. Fletcher, the Dominion Entomologist of Canada, in his Inaugural address, delivered before the third annual

meeting of the Association of Economic Entomologists held at Washington, D. C., made the following remarks which will be a surprise to many readers, yet which are based upon very conservative estimates: "The amount of damage done to crops each year is so vast that the figures exite incredulity from those who do not study crop statistics. The agriculturul products of the United States are estimated at about $3,800,000,000. Of this it is thought that about one-tenth is lost by the ravages of insects. This is in many cases unnecessary. In short a sum of $380,000,000 is given up without a murmur and almost without a struggle by the people of the United States." It would be folly to claim that all of this vast sum could be saved by applying all the means we possees to prevent this loss. But by studying closely the habits of injurious insects, and applying the remedies suggested by such studies at least one-fourth if not one-half of this fearful annual loss could be saved.

Economic entomology teaches two quite distinct methods to combat noxious insects, or in other words it teaches *natural* and *artificial* methods for this purpose. The former are based entirely upon the habits of insects, the latter upon their structure; upon the character of their mouth, whether biting or sucking, and upon the character of the skin, whether soft and easily affected by some chemical substance or hard and tough so as to resist it. Artificial means can be used, such as poison to enter the mouth or skin, or such as none-poisonous substances to cause death in various ways. Both methods can only be applied successfully when the habits and structure of the insects to be combatted are thoroughly known. As a very general rule natural remedies are to be preferred as they are more in harmony with nature, and not so apt, if properly applied, to kill the beneficial insects with the noxious ones.

NATURAL METHODS.

In many cases it is possible to capture some species of insects before they have caused much damage, and if this can be done at the right time it will not require much labor to check future damages.

CATCHING INSECTS BY NETS, BY JARRING AND BY BEATING.

Examples:—The few white Cabbage-butterflies that succeed in passing our winters safely and which appear on the wing in spring near the young cabbage plants can be readily caught by small boys and girls with a butterfly net, which anybody can easily make. By preventing these early butterflies from laying eggs none of the later brood can appear.

The different species of snout-beetles that infest our plum trees hibernate as perfect insects and visit the trees long before any leaves are found upon them.

By jarring the trees early in the morning these insects can be collected upon a sheet of muslin spread under the tree and killed.

By beating the young potato vines the beetles that have collected there to eat and to lay eggs can be gathered into a tin pail containing water with a little kerosene oil, and can thus be destroyed.

CATCHING INSECTS BY TRAPPING AND SEMBLING.

Examples:—Many of the caterpillars of the Codling-moth descend the apple trees to pupate. If a band of folded papers be put around the trunk they will go below this band, where they can readily be crushed.

The males of many destructive moths can be collected and killed by confining a freshly issued female under a sieve. Many males will be attracted to the female and will try to reach her, and while thus engaged can be captured. This method is often very effective, especially with our larger destructive moths.

CATCHING INSECTS BY ATTRACTING THEM TO LIGHT AND BAITS.

Examples:—A large number of injurious insects are attracted to strong lights, as may be seen in cities illuminated with electric lamps. By arranging a vessel with water, upon which floats some kerosene oil, under brightly burning lamps arranged in fields to be protected many destructive insects can be caught and killed.

By using lights many beneficial insects are also captured, most of which might be saved by using water alone.

Baits, consisting of various materials corresponding to

the insects intended to be caught, are very attractive to certain kinds. Sugar or molasses dissolved in water and mixed with a little real vinegar attracts the moths producing cut-worms.

COLLECTING EGGS OF NOXIOUS INSECTS.

In many cases injurious insects can be greatly reduced in number by gathering and destroying their eggs at the proper time.

Examples:—The eggs of Cabbage-butterflies and Potato-beetles can be readily detected upon the young food plants. Eggs of the Tent-caterpillars are prominent during the winter upon the trees that are preferred as food, where they should be collected and burned. The eggs of the Migratory Locusts can sometimes be collected more readily and in larger numbers than the active insect itself.

BURNING DEAD TWIGS IN AND AROUND ORCHARDS.

Example:—The Currant-borers and similar insects remain in the dead or dying canes until mature. By burning canes thus infected in early spring the culprits are killed. The New York-weevil, destructive to plum trees, breeds in oaks, chiefly in those twigs that drop very readily. By gathering and burning these at the proper time the insects are prevented from invading orchards.

BURNING DEAD FOLIAGE, ETC.

Example:—Many insects, for instance the Chinch-bug, hibernate in and below such rubbish. By burning this material at a time when the insects are in a torpid condition they are destroyed. If this operation is carried out very late in autumn they are not very likely to find new hibernating quarters, or are thus exposed without any protection to the cold.

PERMITTING HOGS OR OTHER ANIMALS TO GRUB IN ORCHARDS, WINDBREAKS AND TREE GROVES.

Examples:—The large destructive Willow Saw-fly hibernates just under the surface of the soil, or even above it under rubbish. Their larvæ are readily detected and greedily eaten by hogs, skunks and shrews.

CONCENTRATING INSECTS UPON FAVORITE FOOD PLANTS.

This can be done either by causing some plants in the outer rows to appear earlier than the rest, and thus concentrating upon them the great majority of the noxious insects, or by growing some rows of varieties preferred by them. In either case the insects thus concentrated upon a few plants can be much more readily killed then if scattered over a large field.

HIGH CULTURE.

By manuring or by working the soil more thoroughly the plants grown upon it are stronger and more able to recover from damages caused by insects.

Example:—Young plants of wheat, eaten down to the ground by young locusts, will recover and still produce a good crop if the land was in a prime condition.

REFRAINING FOR ONE OR TWO YEARS FROM CROPS BADLY INFESTED.

Example:—Chinch-bugs in our southern counties forced farmers to abandon the growing of wheat for a number of years. Lack of food, and other causes, destroyed the insects, and wheat can again be grown for some seasons.

Rotation of crops has a similar, but not so thorough an effect upon insects.

SELECTION OF VARIETIES LESS LIABLE TO ATTACK.

This is a very important natural remedy, and can be applied in many cases, but in other cases such unpalatable varieties are as yet unknown, and it is the office of the Experiment Station to make the necessary efforts to find them if they can be discovered.

Diversified farming in infested regions is also very important as in this case it is never likely that all the crops will be destroyed, since nearly all insects are dependent for food upon certain plants, and neither can nor will eat others.

Growing of unpalatable crops in place of others greedily eaten is also a similar natural remedy.

LATE SOWING.

This is also an excellent method to prevent certain noxi-

ous insects from causing injury, and can be applied in many cases and to various crops.

Example:—Late sowing of peas will prevent the Pea-weevil from depositing eggs upon such plants, because the weevils die before the plants are flowering. Keeping seed-peas longer than one year in a tight sack will have the same effect with most species.

EARLY SOWING.

This, if done properly, will enable the plants to attain such growth and strength as to be beyond serious injury.

LATE PLOWING. EARLY PLOWING.

Both methods are sometimes of great value to protect crops grown upon fields thus treated. Late plowing will disturb and kill many insects that are hibernating in the soil. Tender insects and pupæ that can not move are thus killed. Early and repeated plowing will expose many insects otherwise hidden in the ground to the attacks of birds, shrews and other animals.

Example:—The full-grown larvæ and pupæ of Wire-worms are killed by disturbing the soil late in the fall. Young locusts can not reach the surface of the ground if the eggs are plowed under. Late plowing of fallow land is very important, as such fields attract many insects to deposit their eggs, or to hibernate in the undisturbed soil.

Burning stubble at the proper time is also of great value in a number of cases.

Example:—If the standing stubble, or a layer of dry straw, is burned at a time when young locusts are hatched the majority of them will be destroyed. Dry and dense masses of dead grass harbor many injurious insects, such as Chinch-bugs, and should be burned. By burning the stubble we destroy also injurious insects that hibernate in the culms, such as the Frit-fly.

DITCHING.

To prevent such insects as young Locusts, Army-worms, migrating Chinch-bugs and others from reaching fields as yet free from them, ditches prove of great value since the insects are gathered there and can be destroyed in immense quantities in various ways.

Example:—When Army-worms migrate they usually move all in the same direction. A ditch of sufficient depth will soon trap large numbers, and by means of burning straw, kerosene oil, or by dragging a log along the bottom of the ditch the insects can be destroyed.

ISOLATING FIELDS FROM INSECTS.

This can be done in various ways, depending upon the character of the insects to be kept away.

Example:—To protect a corn field from Chinch-bugs that migrate towards it from fields already devastated, a low fence made of a six-inch board, fastened by pins with its edge upon the ground, and having the exposed edge covered with a fluid mixture of oil and tar, will prevent the bugs from crossing. Even a thick rope saturated from time to time with kerosene oil will prevent them from crossing this slight obstruction. The Chinch-bugs, crowding together in front of this obstacle, can be killed in various ways, best by making holes in the ground with augurs, and to close these as soon as filled with insects, and then to make others to take their place.

INUNDATING FIELDS.

Wherever this can be done farmers have almost complete control over a large number of kinds of noxious insects.

MOWING CROPS EARLY.

This remedy can be applied in a number of cases and with very good effect.

Example:—By mowing timothy badly infested with the Lesser Army-worm at a time when these caterpillars are still young, their food is destroyed and the great majority starve to death. Insects infesting the flowers of red clover can be combatted in a similar way.

Other remedies consist of various devices to prevent destructive insects from reaching their food.

Surrounding stems of young plants with paper or a piece of tin to keep away the cut-worms; tacking a strip of tin or tarred paper around trees to prevent the unwinged females of such moths as the Canker-worm from ascending the trees

to deposit their eggs, and other similar contrivances belong here.

INTRODUCING DISEASES

among our injurious insects is receiving now a great deal of attention, and many trials have been more or less successful; yet very much remains to be done in this line of experimentation.

PROTECTING BENEFICIAL MAMMALS, BIRDS AND REPTILES

is one of the best natural remedies we have. It is sad to watch the gradual disappearance of so many of our feathered friends, and the ignorance prevailing in regard to other animals, which are hunted down and killed without mercy, although many of them are our friends. The relation between our wild animals and agriculture has not received that attention which it well deserves. Many animals are considered the greatest enemies of man while in fact they are his benefactors and deserve corresponding treatment.

Many other methods might be enumerated by means of which we can counteract the undue increase of noxious insects, but the above list is sufficient to show that even without the use of poison and machinery much can be done to protect our crops. But we must always study the habits of our enemies, and thus become enabled to select just the one remedy that promises to be effectual. In the warfare against noxious insects there is no royal road which can always be followed.

INTRODUCTION OF PARASITES AND CANNIBAL INSECTS

is also a very promising remedy, in some few and special cases. In a state of nature the relationship between plants and insects is so nicely balanced that each species has a number of checks which prevent undue increase. But even there it sometimes happens that such checks become ineffectual from disease or unfavorable climatic conditions, and as a consequence devastations upon a large scale take place. But as a very general rule the disturbed balance is soon restored to its equilibrium. When man imagines he can improve upon nature by adding, purposely or otherwise, a new factor, or by removing one, most unexpected results may fol-

low. For instance the introduction of the European rabbit into Australia was followed by such deep-rooted disturbances between animals and plants that the whole Australian nation is now forced to fight this animal to regain possession of the agricultural products. The introduction of the English sparrow into the United States is another example, and has already been of sufficient influence to disturb the ancient order of things. So it is with the accidental introduction of foreign noxious insects, as our farmers have learned to their sorrow. As such recently introduced species are usually not accompanied by their enemies these latter ought to be introduced after careful consideration of the case in all its bearings.

To the natural methods to prevent the undue increase of noxious insects might be added proper *laws*. People unwilling to do their share in preventing losses caused by insects ought to be forced by carefully prepared laws to do their duty, if not to themselves, at least to their neighbors and to the community at large. Insects that threaten to become a serious danger to the inhabitants of a whole state should be considered as a public calamity, like some contagious disease, and should be suppressed by every known means.

ARTIFICIAL METHODS,

based upon the structure of insects, are now used very extensively and in most cases with good results. For insects with a biting mouth arsenical poisons are chiefly used. Other poisons are less general in use, but are of great importance in special cases. Insects with a sucking mouth can not be reached with poisons that become active only in their digestive tracts, although some, if applied to soft-skinned species, kill them by contact. Vital organs of sucking insects have to be reached through their skins, either with substances that penetrate through it, or bo closing their spiracles, or by otherwise irritating them to such an extent that they become disabled. Other insecticides combine these properties and still others become active by generating injurious and fatal gases and fumes.

Paris green, London purple and white arsenic are mineral compounds of arsenous acid, and consequently very

poisonous to all organized matter. To use them properly we must recollect that plants can be poisoned by them as well as anlmals, and that they have to be diluted in certain proportions with other substances to make them harmless to plants and yet keep them poisonous enough to kill such insects that eat the foliage covered with them.

PARIS GREEN.

is a chemical combination of arsenious acid and copper, and is called by chemists arsenate of copper. It contains, when pure, about 58 per cent. of arsenious acid. Pure it is insoluble in water, and can be applied either as a dry powder mixed with other substances, or suspended in water. As plants are affected in different degrees by this poison the exact proportions of it and the dilutents can not be given except in a general way. Some plants, as the potato, can be dusted with quite a large amount of it without being greatly injured, while the same amount would kill many other plants, as the plum-trees. Plants made sensative by certain climatic conditions, as by continuous moist and warm weather without sunshine, suffer at such times much more severely by an application of this and similar insecticides than at others. Before applying any arsenical poisons to plants upon a large scale it is always best to try their effects upon a few, so that the mixture can be made just strong enough to kill the insects and not to injure the plants. It has been found that milk of lime almost entirely prevents the injurious effects of arsenical poisons upon the foliage. The addition of a little flour has also a similar benefisial effect and is also of some use in retaining the poison upon the leaves. Milk of lime can be prepared by filling a barrel nearly full of air-slacked lime, and adding to it sufficient water to fill it entirely. After standing undisturbed for some time the clear water above the lime is milk of lime. This can be demonstrated by blowing air from our lungs through it when it will become milky.

DRY APPLICATION.

As a general rule Paris green should be mixed with one hundred times its weight of perfectly dry flour, sifted wood ashes or road dust, land-plaster, air-slacked lime or similar substances. To apply this dry mixture successfully it is

necessary to dust it over the plants at a time when there is no wind, and when the leaves are moist, as they usually are very early in the morning. In this case most of the dust will adhere to the leaves and remain there for a long time. Still any dry application, except upon a small scale, is always a very wasteful one.

WET APPLICATION.

One pound of Paris green to 150 gallons of water is a safe mixture with which to kill nearly all insects that possess a biting mouth; it will not kill the foliage of any cultivated plants grown in Minnesota. If it should become necessary to spray the same plants repeatedly later applications may be reduced in strength. As Paris green does not readily mix with water it should be first made into a paste, and this should be mixed with the amount of water required. Upon the leaves of some plants this fluid will not adhere, as upon the leaves of cabbage. In this case we can overcome the difficulty by adding a little dissolved soap to the mixture.

LONDON PURPLE.

This by-product in the manufacture of aniline colors contains about 43 per cent of arsenite of lime, the rest is composed of Rose aniline, lime, insoluble residue, some little oxide of iron and water. As the material is cheap it would be used much more frequently if it came in convenient packages and not in bulk. At all events it is just as good an insecticide as Paris green, and can be used in the same manner, dry and with water. It is much lighter than Paris Green, more finely divided, remains better in suspension in water, and can therefore be applied more evenly, with less stirring, adheres better to the foliage, and is consequently not so readily blown away by the wind or washed down by rains. As most of the commercial London purple contains some free and soluble arsenious acid we must add some milk of lime to prevent injury to the foliage. If this precaution is kept in mind we have in this substance a very superior insecticide. It has this additional advantage, that it can be used with the Bordeaux mixture and we can add to its effects as an insecticide that of a fungicide. If Paris green is used for a simi-

lar purpose we are very apt to increase its injury upon foliage.

A very good proportion in which to apply London purple is one pound to 200 gallons of water, with an addition of about one pail full of milk of lime. It is always well to mix London purple with the water just before use, and not to leave the mixture standing over night, as may be done safely if Paris green is used. In a dry application we can dilute this insecticide with the same substance as we used with Paris green.

In certain cases, as against the Codling moth, both Paris green and London purple must be applied to the trees before the eggs have been deposited by this insect. By doing so the young larvæ, before reaching the interior of the fruits, have to eat their way through the skins and by eating some of the poisonous material coating the fruit are killed.

WHITE ARSENIC.

White arsenic though very cheap, is too dangerous to use, being more readily mistaken for some edible substances on account of its white color, and also because it is more injurious to foliage, as it is to some extent soluble in water. If it has to be used it should be very much diluted, and the mixture should be applied while quite freshly mixed, and only with a large amount of milk of lime.

In using such virulent poisons as Paris green, London purple and White arsenic it is important to keep in mind the following rules: label the stored material very plainly "*Poison*"; do not handle the poison with your hands; never apply it against the wind; do not use it upon leaves or fruit soon to be eaten; and use it of no greater strength than is absolutely necessary. The following doses of arsenic are dangerous: two grains for an adult, thirty grains for a horse, ten grains for a cow, one-half to one grain for a dog. In cases of poisoning treatment is never hopeless. For persons, give hot milk and and water and tickle the throat with a feather to induce free vomiting. Sugar and magnesia in milk is also a good antidote. Another remedy is also readily prepared: Pour together solutions of Perchloride of

Iron and dilute ammonia; the brown percipitate that forms should be strained off and given with water.

WHITE HELLEBORE.

White hellebore acts both as a poison and as an external irritant. It is a vegetable poison, being a powder made from the roots of an European plant, the *Veratrum album*. Though less poisonous to man and animals it is dangerous to them when fresh; later it seems to loose to a great extent its poisonous qualities. But it is quite harmless if applied to even tender foliage, and is the best insecticide we possess against slugs and false caterpillars, the larvæ of our noxious saw-flies. It can also be applied as a dry power well mixed with such substances as dry road-dust and air-slaked lime, or with water. The usual proportion of a liquid mixture is one ounce to two gallons of water. The insects die when brought in contact with this mixture, or if they eat it with the leaves upon which it is dusted or sprayed.

PERSIAN OR DALMATIAN INSECT-POWDER, PYRETHRUM OR BUHACH.

This is also the product of a number of foreign plants belonging to the genus *Pyrethrum* of the composite plants, which resemble our May-weed. Though almost perfectly harmless to plants and to higher animals it is fatal to insects, at least to all not thoroughly well protected by a very tough skin. It can also be used in the form of dry powder, or suspended in water. It seems that the dry application has the most market effect, and for this purpose it should be mixed with about four times its weight of some finely sifted dilutent. To obtain the best results this mixture should be kept for one or more days in an air-tight vessel before using it. It seems to paralize many insects with which it comes in contact. If used wet the best proportions are one ounce to two gallons of water. This insect-powder is now prepared to some extent in California, where it is called Buhach. Though an excellent insecticide it is very apt to give no satisfaction, as in our markets it is not only very much diluted, but is so poorly cared for that even the unadulterated material soon becomes almost worthless. The

powder should always be kept in an air-tight tin box, otherwise its active principle, an essential oil, will soon escape. As it is, some of our retail druggists expose it in open barrels in their show windows with flaming posters to attract purchasers. Of course if kept in this manner it looses all virtue as an insecticide. In Europe they keep the dried flower-heads until the powder is needed, when they are ground fine. Insect-powder, when pure and fresh, if dusted in a room or stable filled with flies or mosquitoes, will soon kill them. It can also be utilized in the form of tea, as a decoction, as an alcoholic extract, or as a fume, and will be found very useful in certain cases.

TOBACCO.

This well-known plant is a very useful remedy against a number of soft-bodied insects. In green-houses it is a great favorite with gardeners against the insects found there. A decoction, made by boiling a pound of tobacco stems in one gallon of water is a very effective remedy against such insects as flea-beetles and plant-lice. In the form of fine dust it is also of great value against the more tender insects or larvæ. As tobacco stems are very cheap, and are also quite valuable for fertilizers, a more general use of this insecticide is adviceable. As a wash for animals infested with vermin it gives good results, but is inferior to kerosene-emulsion.

FISH-OIL SOAP. WHALE-OIL SOAP.

Both soaps can be bought very cheap, and as they are useful for many purposes ought to be kept ready at hand. Suds made of one pound of such soaps in eight gallons of water are very effective against a large number of soft insects, but chiefly against leaf-lice which succumb very readily. Soft soap, boiled down to the consistency of thick paint forms a tenacious coating for the bark of trees and prevents insects, like borers, from depositing their eggs. If mixed with a little Paris green or London purple it becomes still more effective.

CARBOLIC ACID. COAL TAR. AIR-SLAKED LIME, PLASTER AND WOOD-ASHES.

Carbolic Acid, and the various mixtures that can be

made with it have not proven very good insecticides, yet in special cases they may be used with good results.

Coal-tar is very useful in some cases, not so much as an insecticide but as a repellent and as a means to capture the still unfledged locusts in "hopper-dozers."

Air-slaked lime, plaster and wood-ashes have also some value, and by thoroughly dusting plants infested with soft or slimy bodied insects, many of the latter are killed. Besides, these substances are good fertilizers.

KEROSENE-EMULSION.

Kerosene-oil, though used but for a comparatively short time as an insecticide, has a greater range of usefulness than any other one. It is not a poison but kills by contact. It is a very penetrating fluid and causes almost instant death. But since it kills plants as well as insects it can not be used alone but has to be mixed with some substance that dilutes it without impairing its value as an insecticide. A number of methods are known in which this may be done. One of the best is the "Hubbard formula," which is given below:

"Kerosene, 2 gallons..... 67 per cent.
Common soap, or whale-oil soap, ½ lb... } 33 per cent."
Water, 1 gallon.....

Heat the solution of soap and add it boiling hot to the kerosene. Churn the mixture by means of a force pump and spray muzzle for five or ten minutes. The emulsion, if perfect, forms a cream which thickens on cooling, and should adhere without oiliness to the surface of glass. Dilute before using one part of the emulsion with nine parts of water. The above formula gives three gallons of emulsion and makes, when diluted, thirty gallons of wash." This emulsion is an excellent one when the water used is soft. But with hard water the formula given by Cook is equally good, and for some parts of Minnesota it is better. It is here repeated: "Dissolve one quart of soft soap in two quarts of boiling water. Remove from fire, and while still boiling hot, add one pint of kerosene oil, and immediately agitate with the pump as described above. In two or three minutes the emulsion will be perfect. This should be diluted by adding

an equal amount of water, when it is ready for use. This always emulsifies readily with hard or soft water; always remains permanent, for years even; and is very easily diluted, even in the coldest weather, and without any heating."

All sucking insects that can not be reached by making them eat poisons can be killed by an application of one of the above emulsions. It is most valuable against all kinds of leaf-lice and most scale insects, which latter can not be reached in any other way since they are so well protected by their scales or downy or woolly secretions. Against the various insects infesting the skins of our domestic animals nothing better has as yet been found. Even the hidden scab-mites of sheep readily yield to it. For forming a film upon the surface of rain water in barrels to prevent the breeding of mosquitoes the unmixed oil is best, though any oil will suffice.

BISULPHITE OF CARBON.

There are a number of insects that can not be reached by any of the insecticides mentioned thus far. Insects, for instance, that destroy our stored grain, must be fought by another method, and the above fluid has been found very effective for this purpose, and as it is perfectly harmless to the grain itself no injury can follow if it is applied properly. This fluid is a very volatile substance and its fumes penetrate everywhere. By closing the room containing the stored grain as tight as possible, and by filling this space with the deadly fumes all animal life will soon cease to exist. As the material is inflammable it should never be used near a fire. It is also dangerous to inhale much of it. It is also very useful against other insects that live in the ground, for instance against ants. Even the pocket-gopher can be killed by filling its burrow with such fumes.

Gasoline, *Benzine*, *Oil of Turpentine* and similar volatile substances are also effective if applied to household pests that hide in cracks. Substances such as *Naphthaline*, *Camphor*, *Sublimate of Mercury*, *Powdered Borax*, *Sulphur* and others might be mentioned as insecticides for special cases.

MACHINES TO APPLY INSECTICIDES.

To use any of the insecticides mentioned above three rules should be followed:

1. Never apply more than is absolutely necessary, because otherwise expenses will be greatly increased, and instead of protecting our plants we might injure them.

2. Never wait until too late. Apply as soon as the causes of the injury are recognized.

3. Always apply the insecticides as uniformly as possisible, cover all parts of the plants, both the upper and lower surfaces of the leaves.

As it is not possible to reach all parts of the plants except by means of some specially devised machine, every farmer and fruit grower should possess a spraying machine. Many excellent kinds are now in the market, and the more simple ones are so cheap that the question of expense is of little importance. In buying, attention should be paid to the uses for which the machine is needed, for instance, whether trees or low-growing plants are to be protected. At all events, every machine should have, besides the usual pipe leading to the nozzle, another return pipe, which carries at every stroke of the pump handle a stream back into the tank holding the poison in suspension, otherwise this will settle at the bottom and only the clear and harmless fluid is sprayed over the plants. A second and very important point is to select a good nozzle, one that will not simply sprinkle the fluid over the plants, but that will divide it into such minute parts as to form a genuine spray. Bearing these two necessary qualities of a good force pump and spraying machine in mind the purchaser will have no great difficulty in selecting one that is suitable for his purposes.

In closing this bulletin I should like to add that the entomologist of this Experiment Station is not only willing but anxious to assist all farmers in their war of extermination against noxious insects. In order that he may do so effectually farmers seeking advice should always send specimens of the insects which trouble them, with specimens of their food-plants and also any observations they may have made. Otherwise the entomologist cannot be certain which one of the many species of noxious insects is the real culprit.

OTTO LUGGER.

NOTE.—Most of the illustrations are copied from the superb works of Prof. Dr. E. L. Taschenberg. Fig. 45 and 67 were purchased from C. V. Riley. Fig. 57 was kindly loaned by H. Gorman; and still others are original.

Feb, 23, 1894

University of Minnesota.

Agricultural Experiment Station.

BULLETIN No. 29.

CHEMICAL DIVISION.

DECEMBER, 1893.

WHEAT.

I. Heavy and Light Weight Seed Wheat.

II. The Vigor of Growth of the Wheat Plant.

III. The Draft of the Wheat Plant Upon the Soil in Different Stages of its Growth.

☞ The Bulletins of this Station are mailed free to all residents of the State who make application for them.

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I. HEAVY AND LIGHT WEIGHT SEED WHEAT.

BY HARRY SNYDER.

Experiments conducted at this station and elsewhere have shown that good, heavy weight wheat gives better results for seed purposes than light weight wheat of the same variety. Among the more important results that can be cited in this connection are those obtained by Hellriegel, who showed that the heavier the seed the more vigorous is the young plant, and where there was not an over-abundance of plant food in the soil the differences in vigor of the plants are traced even up to the time of harvest.

In order to determine in what way the causes of these differences are due to differences in chemical composition between the heavy and light weight wheat, twelve samples were secured ranging in weight from fifty-five to sixty-five pounds per bushel. These samples of wheat were all grown from one lot of seed, and in different parts of the state. They are some of the crops from the seed wheat donated by Hon. C. A. Pillsbury in 1891. The differences in grade and weight per bushel of these wheat samples are due to differences in soil, climate, and methods of cultivation, and not due to seed.

The important differences that are to be noted as to the amount of reserve plant food stored up in each kind of grain, are observed among the separate mineral matters that are found in the ash and taken from the soil. Every hundred pounds of wheat, whether light or heavy weight contains about two pounds mineral matter, but the separate compounds such as potash and phosphates are present in quite different amounts in the two cases, as will be seen from the table at the close of this article. The heavy weight wheat, pound for pound, contains more phosphoric acid and potash, and less of nearly all of the other elements than the light weight seed.

The differences from one sample to another are not in mathematical order, but there is the gradual tendency for the low-weight wheats to contain less potash and phosphoric acid, and more soda, silica, chlorine, and iron than the heavy weight seed. When the results of each are calculated to bushels, it will be found that the heaviest weight wheat yields 1.30 lbs of ash, containing .66 lbs of phosphates; while a bushel of the light weight wheat yields 1.15 lbs of ash containing .51 lbs of phosphates. There is nearly thirty per cent more phosphoric acid in the heavy weight wheat than in the light weight of the same variety. The heavy weight bushel also contains about a quarter of a pound more nitrogen than the light weight bushel.

Briefly stated; the heavy weight wheat seed contains more valuable food material for the young plant in the form of nitrogen, phosphates and potash than the light weight wheat. These reserve materials are more abundant in the heavy seeds by nearly thirty per cent, and are supplied to the young plants as just so much more reserve food, before the young plants are compelled to work for themselves, which accounts for the fact that the heavy weight seeds produce more vigorous plants than the light weight seeds. Independent of all this, the additional fertilizer material in the heavy weight wheat is worth about four cents per bushel.

TABLE I.—COMPOSITION OF THE ASH OF HEAVY AND LIGHT WEIGHT WHEAT.

This wheat was all ground from one lot of seed, in different parts of the state.

	Weight per Bushel.	Total Ash in Wheat.	Potash.	Soda.	Lime.	Magnesia.	Iron.	Phosphates.	Silica.	Sulphates	Chlorides.	Carbon Dioxide.
1	65 lbs.	2.00	30.44	.50	3.12	12.10	.41	50.83	.76	.11	.13	1.30
2	65 "	1.91	32.46	.67	2.55	12.39	.27	50.76	.37	.06	.11	.....
3	64 "	2.02	31.85	.86	3.16	12.54	.38	50.95	.09	.....	.04	.11
4	63 "	2.07	30.45	.06	3.00	12.10	.34	50.95	.24	.10	.10	1.64
5	63 "	1.94	31.29	.09	3.89	12.54	.29	50.60	.26	.07	10	.....
6	62 "	2.04	31.16	.62	3.16	12.62	.34	48.86	.35	.06	.11	1.96
7	61 "	1.92	30.02	.74	3.06	13.17	.62	48.04	.39	.09	.09	2.12
8	60 "	2.10	30.16	.26	3.02	12.86	.44	48.10	.27	.71	.07	2.86
9	59 "	2.08	29.01	.89	3.91	13.48	1.16	45.18	1.12	.16	.14	2.99
10	58 "	2.16	28 86	1.45	3.86	14.90	1.33	44.17	1.35	.10	.13	.....
11	57 "	2.05	28.41	.79	4.81	15.30	.81	43.52	1.67	.11	.47	3.04
12	55 "	2.09	28.77	.88	4.52	14.48	.86	43.07	1.92	.12	.42	3.02

Explanation of Table.—Under the head of total ash in the wheat is given the number of pounds of ash in every 100 pounds of wheat; the figures given for the potash, lime, etc., are the per cents of potash, lime, etc., that was found by analyses of each ash.

II. WHEAT PLANT—VIGOR OF GROWTH.

The differences between the heavy and the light weight wheat from the same seed source are so marked, that it is of great importance to know whether these characteristics can be traced to the plants, and what the differences in chemical composition are between the healthy and vigorous, and the poor and sickly wheat plants.

At harvest time a sample of thrifty, stocky, vigorous plants, straw four feet long, heads well filled and over four inches in length, was selected, and at the same time another sample of weak, sickly plants, straw about two feet long, heads two inches long, was sorted out from the same field. A complete chemical analysis was made of each sample.

900 thrifty plants gave about 3 pounds dry matter.

900 sickly plants gave about 1.2 pounds dry matter.

In the same weight of dry matter of each lot there was more nitrogen, phosphoric acid and potash in the healthy and vigorous plants than in the sickly ones, which contained more silica, soda and magnesia. These are the same general characteristics that are noted between the heavy and light weight wheat.

When the results are calculated to 900 entire plants, about the average yield per square yard of a good wheat crop, the differences are even more characteristic. The weak and sickly plants at maturity contained less total ash by nearly one half, than did the average wheat crop in the first fifty days of its growth. Some of the individual compounds of the ash show even greater differences.

In regard to the form of the nitrogen in both lots it is to be noted that in the healthy ones 87 per cent is in the form of gluten, while only 75 per cent is in this form in the sickly

ones. Evidently the plants did not possess enough vitality to reach full maturity and change the nitrogen from the amide to the gluten form.

In order to compare these two lots of wheat, it is necessary to note first the percentage composition, which gives an equal basis for comparison, pound for pound of the dry matter, and then consider the total amount that is present in an equal number of each kind of plants.

TABLE II.

	Percentage Composition.		900 Plants.	
	Healthy.	Sickly.	Healthy.	Sickly.
Total Dry Matter			1311.	5 40
Total Nitrogen	1.40	1.30	18.35	7.02
Crude Ash	7.22	6.46	94.65	34.88
Albuminoid Nitrogen	1.22	1.02	15.99	5.50
Fiber	25.90	26.44		
Chlorophyl, Fat, Etc	2.55	2.69		
Silica	49.38	59.46	46.73	20.74
Potash	22.81	12.72	21.59	4.44
Soda	1.44	1.84	1.38	64
Lime	3.16	4.28	2.99	1.49
Magnesia	2.62	5.11	2.48	1.78
Iron	.30	.44	.28	.15
Aluminia	.05	.07	.04	.02
Phosphates	13.46	12.44	12.75	4.33
Sulphates	2.28	2.41	2.28	.56
Chlorides	.94	1.04	.98	.49

The absence of a normal amount of the essential ash elements in wheat is followed by weak, dwarfed, and sickly plants; these essential ash elements are furnished in greater abundance in heavy seeds than in light weight seeds.

III. THE DRAFT OF THE WHEAT PLANT UPON THE SOIL IN THE DIFFERENT STAGES OF ITS GROWTH.

In the growth of the wheat plant from the seed to full maturity, it is important to know at about what stages in the growth of the plant the various elements are taken from the soil and the air and put together in the form of gluten and starch, so as to have a definite idea as to what the soil must furnish to the crop at each stage of its growth. During the past two years work has been carried on in the chemical laboratory in order to obtain the necessary data upon this question.

At various intervals during the growth of the wheat plant, a given area of ground was cut, and the entire plants, exeepting the roots were submitted to complete chemical analysis. The number of plants per square yard at each cutting was noted, and then the results were all calculated to a uniform basis of 900 plants per square yard, about the average yield of a good crop. This was found to be quite necessary in order to establish a uniform basis for comparison, since no two square yards of wheat always contain the same number of plants. The main points in the results recorded have been verified with two crops, that of 1892 and 1893. Taken as a whole the two crops represent fairly well the extremes in the conditions to which the wheat crop is subjected. Only those points that are common to both years and have a direct bearing upon the question, are discussed.

The time from seeding to maturity is arbitrarily divided into four periods: fifty, sixty-five, eighty-one and one-hundred and five days respectively from the date of seeding. At the close of this article a table is given in a condensed form setting forth all the important facts in regard to the rate of the growth of the wheat plant and its demands upon the soil.

First Period.—At the end of the first period of fifty days

the plants had reached an average height of eighteen inches. At this time a little less than one half of the total dry matter of the plant had been produced, and this dry matter contained nearly three-quarters of the total mineral matters that were taken from the soil during the entire growth of the crop.

Second Period.—Fifteen days later, sixty-five days from the time of seeding, the plants were fully headed out and had made an additioual gain of about fifteen per cent organic matter; the mineral matters were taken up more slowly, showing an additional gain of about ten per cent. At the close of this period (July 15.) the wheat plant had taken up about eighty-five per cent of the total materials supplied by the soil.

Third Period.—At this time the wheat had reached that state as commonly known as "in the milk." During this period of fifteen days, from July 15 to about August 1, the plants showed rapid and marked gains in organic matter, over one third of organic compounds of the plant being produced during these dates. Along with this gain of organic matter, it is to be noted that practically all of the remainder of the mineral matters were taken from the soil.

Fourth Period.—In the last period of some twenty days prior to harvest there was an additional gain of ten per cent of organic matter, and no material increase in mineral matters. This is more of a period of rearrangement of the materials that are already in the plant rather than a period of increase in dry matter.

The important points to be noted from these various periods are, that the ash elements are assimilated quite in advance of the formation of organic matter, in fact the wheat plant makes its heaviest drafts upon the soil during the first fifty days of its growth, and takes but little mineral food from the soil during the last stages of its growth. This means that the food supplied by the soil to the wheat must be in such a condition so that the plant can readily take up over three-fourths of it before the first of July. There may be an abundance of phosphates, nitrogen, and potash in the soil, but if by poor cultivation, very late plowing, continued cropping without rotation, and poor general management

all of the available plant food is used up, the wheat plant cannot wait for more food to become available.

The separate compounds of the ash of the wheat plant that require consideration are: Silica (sand), potash, lime, magnesia, iron, aluminia, phosphates, sulphates, and chlorides. These compounds together with the nitrogen constitute the materials that are supplied by the soil. The essential ash elements as they are called, are not all taken up by the plant at the same time, some are taken up much more rapidly and at earlier stages than others.

Phosphates.—Nearly eighty per cent of the phosphates were taken up in the first fifty days. In the second period, a small amount, while in the third period nearly all of the remainder, about fifteen per cent, found its way into the plant. From eighteen to twenty-five pounds of phosphates are removed per acre of wheat, and about two-thirds of this amount is in the grain. The loss of phosphates by continuous cropping, becomes a serious question in time.

Silica.—In each period a little over half of the ash of the whole plant is silica (sand). A large portion of it, over seventy per cent, is taken up in the first period with marked additional gains in the second and third periods. From seventy-five to one hundred pounds of silica are removed in an acre of wheat, nearly all of it is in the straw and less than one per cent is in the grain. There is an abundance of silica in our soils, in fact it is the most abundant material that we have. Analysis of over one hundred typical wheat soils made in the laboratory of this station during the past year, have shown from five to forty per cent of hydrated silicates in addition to that which is present in the form of sand and clay. The lack of stiffness of straw, reported in so many cases, can not be due to a loss of silica from the soil, nor to its absence from the plant. Analysis of the straw from badly lodge grains have always shown as much silica, and in some cases even more, than in the grains that have not lodged. Whether this serious trouble is due to the absence of any material from the plant, is now receiving its due attention.

Sodium, Chlorine, Iron and Aluminia.—These

compounds are taken up in very small amounts and in the first period. Excepting the iron, these compounds are of far less vital importance to the plant, than the other ash elements. These compounds are found in the grain only in very small amounts, and there is always sufficient even in the poorest soils for all the demands of the crop.

Lime and Magnesia.—The lime is taken up at comparatively much earlier periods than the magnesia. The magnesia, it is to be noted, is stored up in the seed more liberally by three fold than the lime. From eight to ten pounds of lime are removed per acre and about eight-ninths of it is removed in the straw crop. The magnesia, which is found largely in the seed is assimilated more slowly and at later periods. The question as to the amount of lime in our soils and the use of lime fertilizers is too long to be discussed in this bulletin.

Potash.—About three quarters of the potash finds its way in the plant at the end of the first fifty days. The rate of the assimilation of the potash is, to a great extent, a measure of the degree of vigor of the plant. The gains in potash in the second and third periods are gradual and uniform. It is to be noted in particular that there is more potash in the plant at the end of the third period by six and one half per cent than at harvest time. In the growing plant potash is found largely in the upper extremities, and when the plant matures there is a gradual downward movement of the potash from the seed into the straw. More potash is carried off in the straw crop than in the grain crop. It appears that this well established retrograde movement of the potash is carried even further, some of it even to the roots. In both trials this point was distinctly marked. In similar work on the oat plant by *Ardent*, and particularly in the corn plant work by *Schweitzer* these same points are observed in the analysis. This appears to be a characteristic of these crops so as not to exhaust the soil too rapidly, and means that a larger working supply of potash must be in the soil than the mere amounts taken off in the crop.

Gluten.—The most essential building materials of which the gluten is composed are assimilated in the early

stages of growth, although they are not put together by the plant in the form of gluten until the end of the third period. The nitrogen—the important building material of the gluten —is assimulated even more rapidly than the mineral matters taken as a whole; about eighty-six per cent of nitrogen was taken up at the end of the first fifty days. Next to the nitrogen the phosphates were assimilated the most rapidly. In the third period the formation of the gluten is distinctly marked. At the time the wheat was head-out about sixty-five per cent of the nitrogen was in forms allied to gluten, about the same amount as at the end of the first period, but in the third period there is a change of over twenty per cent of the nitrogen from amide to gluten forms.

Of all the food that the soil supplies to the wheat plant the nitrogen must be in the most available form. The chief benefits of summer fallow are due to the additional time and more favorable conditions given for the process of rendering the nitrogen available. In the wheat soils that have been under cultivation for ten years or more there is about a quarter of one per cent of nitrogen present, but it is not safe to count on more than one per cent of this as being available at any one time for crop purposes. From thirty-five to fifty pounds of nitrogen per acre are required for an average crop of wheat.

The opinion is held by many that our wheat producing soils are practically inexhaustible—that this is not the case a simple calculation will show. The average prairie and wheat producing soils weigh about 3,260,000 pounds per acre to the depth of one foot, and contains about 6,500 pounds of nitrogen; at least 50 pounds per year of nitrogen is lost either in the crop or in various other ways. So that only one hundred and twenty-five or thirty crops can be counted upon if all of the nitrogen in time was to become available and none lost, which can not be expected to occur in either case. Allowing the largest factor admissable—that only one per cent of this nitrogen can be counted upon for grain crop purposes, and it will be seen that the time when the nitrogen ceases to be present in sufficient available quantities is not such a great way off. This question will

receive a more thorough discussion in the following bulletin on the chemical composition of our soils.

Fiber.—The fiber (woody material) is formed largely in the first and second periods, and none in the last period; in fact the last period shows a slight loss which is probably due to the transformation of the fiber into other allied forms of carbhydrates, such as starch.

The chlorophyl, fat and gums, designated as the ether extract, forms such a hetrogeneous mixture that nothing definite can be said about them.

Starch.—The starch that is stored up in the seed is formed mainly in the second and third periods, a small portion being formed well along in the last period.

The wheat plant is capable of doing a certain amount of work and procuring its own mineral food, provided it is present in the soil; and it is not dependent upon the mineral food that is simply offered to it in solution. The wheat plant is to be looked at as a working organism and not as having its food "pumped into it." One of the best proofs that we have as to this point is the fact that the soil in which this wheat was grown contained more soluble lime, magnesia, and soda, than it did of either potash, nitrogen and phosphates, but notwithstanding this fact the wheat plant took up much larger quantities of these three elements than of any of the others that were present in the soil in larger and more soluble amounts. In order to accomplish this, the wheat plant must certainly have performed a certain amount of work, not only to procure the food required, but also to reject what was not required.

In the following table is given the average draft of the wheat crop upon the soil at the rate of eighteen bushels per acre, and the compounds that are removed separately in the straw and chaff, and in the grain. Lessened yields, as during the past year, would of course remove correspondently less amounts.

TABLE III.

	Grain.	Straw.	Total.
Total Mineral Matters	22.	178.	200.
Silica (sand)	.1	114.	114.1
Potash	6.5	26.5	32.
Soda	.1	3.	3.1
Lime	.7	6.3	7.
Magnesia	2.8	2.7	5.5
Phosphates	12.40	7.6	20.
Chlorides	.1	1.6	1.7
Sulphates	(2.)	2.8	4.8
Total Nitrogen	25.	10.	35.

In the table on the following page is given the comparative drafts of the wheat plant upon the soil at each of the four periods of its growth. In the first column of figures for each period is given the total weight in grams of each of the organic compounds and ash elements found in nine hundred plants at the end of that period. In the second column headed "Gain" is given the gain in grams of weight for that period, and is obtained by subtracting the total of the previous period from the total of the period in question. Finally in the last column headed "Per cent", is given the percentage amount of the total, of each element and compound, assimilated up to the close of that period. For comparative purposes the reduction to ounces per square rod is unnecessary. One ounce equals 28.3 grams.

TABLE IV.—WHEAT. ANALRSES OF ENTIRE PLANT.

Nine hundred entire wheat plants, the average yield per square yard of a good crop. All of the weights in the column headed "Total" are in grams.

	50 Days.		65 Days.—Headed Out.			81 Days.—In Milk			Harvest Time		
	Total	Per Cent.	Total	Gain	Per Cent.	Total	Gain	Per Cent.	Total	Gain	Per Cent.
Total Dry Matter	486.2	45.85	650.	163.8	58.77	1012.	362.	95.45	1106.	94.	100.
Total Nitrogen	13.12	85.97	13.52	.40	88.60	14.56	1.04	95.42	15.26	.70	100.
Gluten Nitrogen	8.26	63.50	8.78	.52	67.33	12.34	3.56	94.63	13.04	.70	100.
Chlorophyl, Fat and Gum	41.46		21.12			36.12			34.38		
Fiber	134.44	44.88	209.48	75.04	69.96	299.46	89.98	100.	294.64	4.82	98.37
Dry Organic Matter	440.35	43.48	579.11	138.76	57.16	916.53	337.42	90.47	1013.12	96.59	100.
Silica (sand)	32.40	72.48	35.34	2.94	79.24	43.96	8.62	98.34	44.7	.74	100.
Potash	14.20	74.71	16.84	2.63	88.54	19.02	2.18	100.	17.8	1.22	93.6
Soda	.94	94.	1.02	.08	100.	.96	.06	.96	.86	.14	86.
Lime	2.86	67.77	3.86	1.00	91.47	4.22	.36	100.	4.06	16	95.7
Magnesia	1.88	56.97	3.12	2.24	67.88	3.28	.16	99.4	3.30	.02	100.
Iron (oxide)	.06	100.							.04		
Aluminia	.04	100.							.04		100.
Phosphates	8.10	79.57	8.48	.38	83.30	10.16	1.68	97.87	10.18	.02	100.
Sulphates	.64	59.26	.96	.32	88.89	.96		88.89	1.08	.12	100.
Chlorides	.81	84.38	.96	.15	100.	.91	.05	94.80	.82	.09	85.5
Pure Ash	61.94	74.10	70.89	8.85	84.83	83.56	12.67	100.	82.88	.68	99.2

SUMMARY.

1. Heavy weight seed wheat contains a larger quantity of more valuable food materials for the young plant in the form of nitrogen, phosphoric acid and potash, than light weight wheat of the same variety. This additional reserve food is supplied to the young plants, and produces a more vigorous growth.

2. The additional fertilizer material that is present in a bushel of heavy weight wheat is worth from three to five cents more per bushel.

3. The same characteristic differences that are noted between heavy and light weight seed wheat are observed between healthy and vigorous, and poor and sickly wheat plants even at the time of harvest.

4. The wheat plant takes up over three-fouths of its food from the soil before heading out.

5. The soil must be cultivated and managed in such a way so as to supply the growing wheat crop with at least three fourths of its mineral food and seven-eights of its nitrogen before the first of July.

University of Minnesota.

Agricultural Experiment Station.

BULLETIN No. 30.

CHEMICAL DIVISION.

DECEMBER, 1893.

SOILS.

The Composition of Native and Cultivated Soils and the Effects of Continuous Cultivation Upon Their Fertility.

☞ The Bulletins of this Station are mailed free to all residents of the State who make application for them.

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.

EAGLE JOB PRINT, DELANO, MINN.

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SOILS.

THE COMPOSITION OF NATIVE AND CULTIVATED SOILS, AND THE EFFECTS OF CONTINUOUS CULTIVATION UPON THEIR FERTILITY.

BY HARRY SNYDER.

Nature and Extent of the Work.—During the past two years, 1892-1893, chemical analyses have been made of many of the cultivated and uncultivated soils of the state. Some of these soils have been under continuous cultivation from one to thirty-five years, while others from adjoining fields have never been under the plow. The conditions for comparison between these cultivated and uncultivated soils are particularly favorable, especially the prairie soils and portions of the Red River Valley region, where there are townships in which the soil is even and uniform, except that some sections and quarter sections have been under cultivation for a longer period than others. The differences in composition between these cultivated and uncultivated soils are marked, as well as the effects of different methods of treatment; both topics are discussed in this bulletin.

The soils that are represented in this bulletin have been sent in mainly by the farmers of the state, some have been received from the students of the Minnesota School of Agriculture, while a few have been taken by members of the station corps. In all cases the soils have been taken according to uniform directions sent out from the station laboratory. The farmers have taken much care in the sampling of many of these soils, and to them credit is due for their share in this work.

Along with the samples of soil have come a number of important questions: "Will this soil wear well?" "Why does small grain lodge so badly on this kind of soil?" "Does this soil contain enough of all of the compounds essential for the growth of our farm crops?" "Is there enough phosphates in this soil for successful wheat growing?" "Why do our

old and cultivated soils dry out so much more readily than new soils?" "What is the alkali in this soil and how can it be cured?" "Is the lessened yields of wheat for the past few years due to the giving out of the soil?" These, and many more of the same nature, are the questions that the farmers send in with their samples of soil.

We are well aware of the various views that are held in regard to the value of soil analyses, and it is not the intention in this bulletin to enter into the discussion. The complete chemical and physical analyses of the native and cultivated soils, however, have given valuable information as to the effects of continuous cultivation and different methods of rotation that will be of benefit to the farmers.

In all, about one hundred and fifty samples have been analyzed, and in this bulletin only a few typical cases are selected in order to illustrate the various points under discussion. These points have been verified in a number of similar cases so that the reader in following this work is not considering just one single case as it might appear, but the results of a number of similar cases. Long tables and pages of chemical analyses, necessary as they are, do not make very good general reading matter, and in this report they are embodied as little as possible.

Analyses have been made of both the top and the subsoil, in all cases; the top soil has been taken down to a depth of about nine inches, or until a change in color between the soil and sub-soil was observed. The sub-soils furnish such a large amount of plant food that their chemical and physical properties are equally important as in the case of the top soil.

At the outset, it can be said that our soils, with some exceptions, are well supplied with all of the necessary mineral food for farm crops, in forms that can be rendered available by good cultivation, provided that the soils are kept in good condition by grass crops and rotation so that the plant food is present in available conditions.

RED RIVER VALLEY SOILS.

The average top soil in the Red River Valley ranges from eighteen to thirty-six inches in depth, is black in color, very sticky when wet, and when dry it crumbles to a very fine powder. The particles which compose this soil are very fine; all are less than $\frac{1}{40}$th of an inch in diameter, and in some cases even less than $\frac{1}{100}$th of an inch. There are no coarse particles (skeleton) in most of these soils. The native soils are very rich in decaying vegetable and other organic matters, largely due to the accumulation of the crop residues of the native grasses. When these vegetable and other organic matters have reached an intermediate point in their decomposition, they form a class of valuable compounds known as humus, and when the virgin soils are cultivated for a number of years, the humus is gradually consumed by being still farther decomposed. In the uncultivated soils there is usually about five per cent of humus, while in the cultivated soils there is usually less than three per cent. The humus is very rich in nitrogen, the important building material out of which the gluten in wheat and grains is constructed; and when the humus decreases the nitrogen decreases as well and is lost from the soil. The native soils contain from .35 to .40 of a per cent of nitrogen, while the soils that have been under continuous cultivation for twelve or fifteen years, contain from .2 to .3 of a per cent. This is a very unfortunate occurrence because nitrogen is the most expensive material of all of the elements necessary for plant food.

The effects of the humus on the capacity of the soil to retain its water and withstand the evil effects of drought are marked; the native soils will retain about twenty per cent more water than the long cultivated soils, and will not dry out as readily during droughty seasons as the older and long cultivated soils. Another important point: when the humus is taken out of the native soils during the process of analyses, from .06 to .08 of a per cent of phosphoric acid is soluble and associated with it; while only about .02 of a per cent is in this form with the long cultivated soils. Phosphoric acid in this form is very valuable as plant food. There is a good supply of phosphates in all of these soils, but we must keep

up the supply of humus in order to keep the phosphates available.

In the analyses reported, the average amount of potash is given as about one-half of one per cent,—this is not the total potash that is in these soils, in fact there is about one and three-quarters of a per cent in all, but one and a quarter per cent, or over two thirds of the total cannot be counted upon for crop purposes because it is combined with the silica (sand) in the form of minute stony particles, that require the strongest chemicals and the highest heat that can be procured in the laboratory to decompose them. The tables only give the amounts of plant food that are soluble in hot muriatic acid, and is just about the amount that plants can reasonably be expected to procure. Each sample has been analyzed twice, and in some cases three times, using solvents that possess different degress of solvent power, in order to determine the forms in which the mineral matters are present in the soil. The results given are based on all the analyses and not simply on just those that are reported.

There is not a great deal of true sand in these soils; in some localities there is more than in others. None of the soils that are reported, except those that are some distance east of the river, contain more than two per cent of true sand; nearly all of the silica is combined with the aluminia to form clay, or with the potash, soda, and lime to form complex silicates. The lime is present mainly in the form of carbonate of lime—limestone particles, a little is in the form of gypsum. All of these soils are well supplied with lime and magnesia, especially the sub-soils that have a greyish color usually contain from 20 to 30 per cent of lime and magnesium carbonates. It is partly due to the abundance of lime in these soils that they owe their remarkable fertility. The dry soils range in weight from 62 to 66 pounds per cubic foot. The native soils contain more of organic matter and weigh less than the well cultivated soils. In the native soils there are from 8 to 15 pounds of organic matter in every 100 pounds of the air-dry soil, while with the long cultivated soils there are from 5 to 8 pounds of organic matter per 100 of soil. The 85 to 90 pounds of mineral matter in the native soils does not always contain quite as much mineral matter as the 95 pounds in the long cultivated soils. The samples are not compared on quite equal bases to show the full extent of the losses during cultivation because in the cultivated soils, the aluminia, iron oxide, etc., appear to increase; this is because the humus is decomposed and decreases so rapidly. If the cultivated and uncultivated soils were all calculated to

a uniform basis as to the amount of humus, that would not represent the true conditions of the present state of the soil, and would require a duplication of all of the tables in this work, which is not necessary; but even allowing this factor, the losses of the phosphates, potash, and particularly the nitrogen are quite noticeable. The cultivation of these soils has aided in the decomposition of the silicates, but the drafts of the grain crops have been greater than the amount that is annually liberated.

The potash, soda and aluminia and a part of the lime, are present in the form of double hydrated silicates, called zeolites—forms that are available for plant food, and yet insoluble in water and not easily lost from the soils.

The use of commercial fertilizers by Prof. Hays in 1890, on these soils, did not show any marked increase in the yield of grain, and yet neither the fertilized nor the unfertilized plots gave as heavy yields as when the ground was first broken. The fertilizers used did not supply any humus, and the mineral food that was supplied in the fertilizer did not increase the yield of grain. Both analyses and fertilizer experiments show that these soils are well supplied with mineral food, but the analyses show that the humus is decreasing.

The continual cropping of these soils is not telling so heavily on the mineral matters as it is on the humus that is in the soil, and with the loss of humus follows the decrease in nitrogen, the capacity of the soil to retain its water and withstand drought, and finally in the loss of the phosphoric acid in available forms. The crop residues from grain crops is not active enough in decomposing to serve as humus. The supply of humus can be kept up by occasional grass crops, well prepared farm manures, and occasional green manuring.

These are points that are to receive their due attention from the present agriculturist of the station.

Alkali Soils.—In this region little patches of alkali, an eighth of an acre or so in size, are occasionally observed. These alkali patches are sources of trouble, because in the spring of the year when the land is wet these patches can not be observed, and consequently much labor and seed is spent upon them without any immediate returns. The alkali in one of these soils near Crookston was found to be sodium carbonate. The alkali was all near the surface. These plots should be ploughed very deep and the land well drained. Heavy manuring, especially with horse manure that is well rotted, gives good results. The horse manure when it decomposes furnishes humic and other acids that

unite with the alkali. The humus also prevents rapid surface evaporation, and thus aids in preventing the alkali from accumulating near the surface. When horse manure can not be procured, green manuring will be beneficial. This method of treatment has been followed by a number of people in this region, and the results have been "large yields per acre of wheat and oats." When these alkali spots are well cured they are excellent soils, and will withstand drought even better than many other soils. The analyses of an alkali soil is given in the table.

Occasionally the alkali consists of sodium sulphate, commonly known as Glauber's salt, and then again of common salt. These last two substances are not so difficult to contend with as the sodium carbonate (salsoda). When these patches are located so that they can be well drained at comparatively little expense, this should be done, and it will be found to be one of the best and most permanent ways of relief. These alkaline compounds are all soluble in water, and thus in time will be washed out of the soil, provided that the spots are well drained. Where the spots are small, a large amount of the alkali can be removed by scraping off the top in dry times and carting the alkali scrapings away. In very dry times the first inch of the soil will contain from 20 to 30 per cent of the total alkali that is in the soil. The deep ploughing affords relief by removing the alkali from the surface where it destroys the young and tender roots of plants.

These soils will improve with every crop that is removed; and when cured will produce crops that will repay all of the time and labor that has been spent.

Gumbo Soils.—This is the popular term applied to a certain class of very heavy soils, that are "waxy" when wet and through which water percolates with much difficulty. The particles that compose these soils are very fine, less than $\frac{1}{100}$th of an inch in size; there is no true sand present. These soils are rich in alkaline compounds, particularly potassium salts. It is the alkali in these soils that gives rise to the soapy and waxy appearance and "feel" when wet. They fail to scour the plow on account of the absence of true sand and the fineness of division of the soil particles. There is too much of the rich alkaline salts present. Lime fertilizers and amendments are not applicable to these soils as they will only make matters worse by rendering the soils more waxy. As yet, no cheap chemicals can be suggested for their improvement. They will improve with cultivation, the deeper the better, and with the loss of the alkali from the soil that is removed in the crops. They are especially adapted for grass and hay crops.

Marshy and Peaty Soils.—The soils from the low marshy places along the water courses are unusually rich in organic matter. They are easily reclaimed on account of the large amount of lime that is present that prevents the formation of "sour mould." One peaty soil contained over fifty per cent of organic matter; it would not require much more combustible matter to make a good fuel peat. There are large tracts of this land being opened up by making large drains through the Beltrami and other marshes.

In the table of analyses reported, the figures given are the number of pounds, or fractions thereof, of potash, lime, etc., that are present in every hundred pounds of the soil, or the amount that is in every one and two-thirds cubic feet of these soils. The figures show that in every hundred pounds of the top soils, there is on the average, a little over half a pound of potash, two and one half pounds of lime, over a third of a pound of phosphates and nitrogen, together with larger amounts of silica, aluminia, etc.,as noted in the table. No exact figures can be set down as to just how much or how little every soil should contain, suffice it to say, however, that all of the necessary mineral elements are present in much larger amounts than the limits usually allowed for any one compound.

Soil samples number 298, 299, 203, and 204 were taken from Marshall county, about five miles west from Warren. Sample 203 has never been under the plow while 298 is from an adjoining plot that has been under cultivation for ten years. Analyses of the corresponding sub-soils are given.

Soil samples 202, 205, 236 and 237 are from Polk county, four miles west from Crookston in the direction of Fisher; 202 is a sample of native soil, while 236, from an adjoining plot, has raised ten crops of small grain. The composition of the corresponding sub-soils is given; sample 201 is a fair example of "alkali soil," taken a short distance east from Crookston, while 272 is a type of "Gumbo," taken north-west from Crookston.

Prof. Hays,who has had much experience in the working of these soils from the Red River Valley says "that they do not puddle and bake like many clay soils, that when puddled and then dried, a little rain, or even the moisture absorbed from the air will cause the lumps to slake like lime."

TABLE I.—SOILS FROM THE RED RIVER VALLEY.

Kind of Soil	Native. Warren.		Cultivated. Warren.		Native. Crookston.		Cultivated. Crookston.		Native. Crookston.		Native. Barnesville.	
Where from												
Top Soil or Sub-Soil	Top	Sub	Top	Sub	Top	Sub	Top	Sub	Alkali	Gumbo	Swampy	Peaty
Number of Soil	203	204	298	299	202	205	236	237	201	272	206	207
Weight per cubic foot	62	65	64	65	58	63	60	63	65	65	39	35
Fine Earth	100	100	100	100	100	100	100	100	100	100	.....	.....
Skeleton	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Humus	5.34	.89	3.02	.78	5.16	.81	2.87	.74	.....	5.16	5.94	5.88
Capacity to retain water	75.	63.	58.	62.	71.	54.	64.	54.	.....	59.	139.	130.
Total Nitrogen	.38	.11	.25	.11	.41	.11	.20	.11	.....	.38	.52	.49
Phosphates associated with Humus	.07	.02	.03	.01	.06	.06	.03	.01	.....	.03	.06	.02
Insoluble Silica and Silicates	47.64	41.21	55.12	40.26	60.20	39.17	58.48	37.25	73.16	60.21	14.33	12.60
Combined Silica	15.43	8.37	16.92	8.98	9.82	15.09	13.05	15.72	10.54	9.00	5.37	5.80
Potash	.54	.25	.50	.20	.60	.60	.54	.61	.65	.90	.44	.40
Soda	.45	.48	.41	.46	.41	.46	.45	.42	1.05	.61	.30	.21
Lime	2.44	7.45	2.40	7.67	2.55	8.10	2.49	7.92	.85	1.07	23.27	12.20
Magnesia	1.85	4.48	1.91	4.62	.67	2.04	.62	2.12	.82	.84	.80	64
Iron (Oxide)	4.18	3.48	4.20	3.51	4.00	3.98	4.04	4.02	1.98	3.49	.55	.42
Aluminia	7.89	10.72	8.81	11.76	8.10	13.61	8.15	13.50	5.50	9.15	2.70	1.60
Phosphates	.38	.17	.31	.15	.29	.22	.24	.24	.22	.13	.30	.21
Sulphates	.11	.10	.10	.10	.11	.06	.11	.10	.07	.11	.75	.22
Carbonates	2.42	14.26	2.45	14.64	4.51	13.27	4.40	13.24	.63	.13	23.00	12 60
Chlorides	.03	.04	.02	.04	.02	.03	.02	.03	.07	.01	.09	.04
Volatile	15.55	6.22	5.58	6.20	8.10	3.20	5.48	4.22	3.90	14.29	27.72	52.60
Total	98.91	97.23	98.73	98.59	99.38	99.85	98.17	98.39	99.64	99.94	99.62	99.50

In order to complete the series, three additional types of soil are added. One from Twin Valley, Norman county, of a sandy nature, which is particularly noticeable as regards the combined silica This soil has produced seven crops of wheat and oats with one year of fallow. Samples 308 and 309 are from Gossen, Polk Co.; this soil has raised eight crops of grain. It is not as sandy as the sample from Twin Valley; the sub-soil is more of a clayey nature. The sample from Moorhead is a type of the soils near the river, it has raised six crops in all, and in chemical composition is more like the soils from the places given in the following table.

TABLE II.

Where from	Twin Valley.		Gossen.		Moorhead.	
Top Soil and Sub-Soil... Number of Soil	Top 306	Sub 307	Top 308	Sub 309	Top 275	Sub 276
Weight per cubic foot	81.	87.7	75.8	85.	65.2	65.2
Fine Earth	100.	100.	98.	98.	100.	100.
Skeleton			.02	.02		
Humus	2.12		3.16		4.04	
Capacity to retain water	48.	39.	57.	43.	70.	56.
Total Nitrogen	.14	.06	.25	.09	.37	.17
Phosphates associated with humus	.03		.03		.05	
Insoluble sand and Silicates	87.74	90.36	74.36	66.53	59.19	45.06
Combined Silica	3.41	3.19	5.44	14.11	12.02	16.43
Potash	.18	.17	.30	.30	.73	.81
Soda	.21	.18	.18	.20	.44	.27
Lime	.48	.44	1.20	1.22	1.29	8.84
Magnesia	.25	.24	.80	.74	.39	3.02
Iron Oxide	1.41	1.38	2.30	3.52	4.07	4.22
Aluminia	1.63	1.67	4.77	6.31	9.33	10.20
Phosphates	.13	.20	.19	.20	.20	.27
Sulphates	.13	.10	.11	.06	.09	.09
Carbonates			.14	.11	.10	7.22
Chlorides	.01	.01	.01	.01	.01	.01
Volatile	4.50	1.72	9.67	5.30	12.05	2.61
Total	100.08	99.66	99.47	98.62	99.91	99.04

WESTERN AND CENTRAL PRAIRIE SOILS.

The prairie soils of the Western and Central portion of the state differ quite materially in the way in which the plant food is stored up, as compared with the soils from the Red River Valley region. The soil particles are a little larger, and there is more silica in the form of sand. Some of the soils are of a more sandy nature than others, and in some localities a number of different types of soil will be found on the same farm. In the soil work, it has been the aim to include samples of all of the types. The most general type that we have to deal with is the black prairie soil ranging from one to three feet in depth resting upon a layer of yellow clay. The top soils are lighter and weigh from 70 to 75 pounds per cubic foot when perfectly dry; when of a sandy nature the weight is greater. The yellow sub-soils range in weight from 75 to 85 pounds per cubic foot, depending upon the proportion of sand and clay that is present.

These soils are quite well supplied with lime, although not to such a liberal extent as the soils already referred to; there is a sufficient amount, however, for all ordinary demands provided that the soils are not too severely taxed in any one line of crop raising. The sub-soils are somewhat better supplied with both potash and lime than the top soils, while the top soils are more liberally supplied with phosphates, humus, and nitrogen. In the management of farm crops this fact should be kept well in mind, and the crops rotated in such a way that the potash and lime in the sub-soil, and the phosphates and nitrogen in the top soil are alternately and evenly drawn upon. Clover, provided its growth is made a success, is an excellent crop for this purpose, also field peas.

The continuous cropping of these soils is telling upon the humus in the same way as with the soils already referred to. In some cases the nitrogen is less than .20 of a per cent. As a good illustration of this point, take for an example, the sample of prairie soil (No. 224, Table III.) that has never been under cultivation, compare it with sample No. 312 taken from an adjoining plot that has raised ten successive crops of wheat and note how the humus and total nitrogen have decreased, a smaller amount of phosphates associated

with the humus, and finally how the soil has decreased in ability to retain its water.

The loss of the humus and the other organic matters from the cultivated soils will soon be felt in another way. When the humus and other organic matters decompose they furnish liberal amounts of carbon dioxide to the air that is in the pores of the soil. This carbon dioxide, the same gas that is given off in respired air, acts upon the complex mineral matters and aids in rendering them available as plant food. In one sample of native prairie soil containing four per cent of humus, there was produced during the six months' trial, .84 per cent of free carbon dioxide, over twenty times the amount that is in the air that we breath. A sample of long cultivated soil with 1.84 per cent humus, gave .21 per cent carbon dioxide, while a sample of sandy soil with but little organic matter gave only .09 of a per cent of carbon dioxide. The humus in the soil aids in keeping up the supply of carbon dioxide, which is one of the active chemical agents that renders the plant food available.

Since the nitrogen decreases so rapidly in the cultivated soils, we naturally ask—"what becomes of it?" One of the chief causes of the rapid decrease of the humus and nitrogen from the new soil, is the unusual activity of the micro organism in these soils in producing nitrates and nitrites. This is extremely beneficial to the growing crop while it lasts, but the trouble is, it is too active at first, producing too rank a growth of straw, and then is not active enough when the soils become older. These micro organisms which take such an important part in rendering plant food available, perform their work under the most favorable conditions, being well supplied with phosphates, nitrogenous matter, lime, and other alkaline compounds. The soil extracts (leachings) from ten samples of soil produced nitrification in a sterile ammonium chloride solution in from one to five days.

The indirect action of land plaster (gypsum) on these soils in liberating plant food, particularly potash and phosphoric acid, is unusually marked. Experiments conducted in the laboratory have shown that small amounts of gypsum are quite active in rendering potash, phosphoric acid, and even nitrogen soluble in the soil water. It is not the land plaster, itself, that furnishes the food, but it is the power that it possesses in making the mineral matters available, that are already in the soil. Land plaster acts more as a stimulant and not as a direct fertilizer, and if not used to excess it will be a profitable fertilizer to use on these soils especially to bring in grass and clover.

The association of the phosphates and the humus in these soils is marked. In the native soils from .05 to .06 of a per cent of phosphates is associated with the humus, while only .01 to .02 of a per cent is present in that form in the continuously grain cultivated soils.

Soil sample number 224 is a good type of the native prairie soil. It is from Marshall, Lyon county, and has never been under cultivation, while sample 312 has been under continuous, cultivation mainly to wheat, for ten years. Sample number 222 is from Sleepy Eye, Brown county, and has raised five grain crops with one year fallow. The soil from Sacred Heart, number 259, has been cultivated for twenty-two years. Instead of continuous wheat, oats, corn, and other grains have been grown, with an occasional grass crop, and frequent applications of farm manures. Although there is no native soil from the same locality to compare it with, yet the humus and the nitrogen in this soil are as high as in most of the soils that have produced only half as many crops. The good treatment of this soil has shown itself as plainly as the good treatment of a farm animal.

Soil number 249 is a sample that has produced flax for a number of years, "until the flax won't grow any more." The total nitrogen is a little lower than in most of the soils of this nature, but the amount that remains would be called very high for some localities, and is far from indicating an exhausted soil.

Sample number 298 is from Grafton, Sibley county; it has produced seven crops including one crop of flax, and has been fallow one year.

Another type of soils frequently met with, is the reclaimed soils bordering on the edges of the numerous lakes of the central portion of the state, and those soils that are commonly known as old lake bottoms, formed by the filling up and draining of old lakes and water courses. Two types of these soils are given. Number 326 is reclaimed land from the border of the lake at Worthington, Nobles county, and has been under high cultivation for about nine years, and in addition to its stock of native fertility has received very liberal dressings of farm manure. Soils of this class are particularly rich in limestone, the sub soil frequently containing from twenty to thirty per cent of this material.

TABLE III.—WESTERN AND CENTRAL PRAIRIE SOILS.

Kind of Soil	Native Prairie.		Cultivated.		Cultivated.		Cultivated.		Old Flax Soil.		Prairie.	
Top Soil or Sub-Soil	Top	Sub	Top	Sub	Top	Sub	Top	Sub	Top	Sub	Top	Sub
Number of Soil	224	225	312	313	222	223	259	260	249	250	298	299
Weight per cubic foot	72.	78.	74.	81.	70.	76.	72.	78.	85.	94.	71.	75.
Fine Earth	98.	98.	92.5	91.	93.	93.	94.	93.	100.	100.	97.	95.
Skeleton	2.	2.	7.5	9.	7.	7.	6.	7.	.....	.....	3.	5.
Humus	5.12	.....	2.60	.....	3.42	.....	2.61	.....	2.04	.....	4.92	.....
Total Nitrogen	.38	.22	.22	.09	.28	.10	.20	.11	.17	.08	.41	.25
Capacity to retain water	59.	51.	49.	51.	50.	51.	51.	49.	48.	58.	61.	54.
Phosphates associated with Humus	.05	.....	.03	.....	.02	.....	.02	.....	.02	.....	.06	.....
Insoluble Silicates and Sand	72.30	73.95	70.75	73.77	64.08	65.61	69.85	68.54	74.77	74.82	63.77	67.06
Combined Silica	6.77	6.58	10.14	11.71	13.16	13.36	8.62	11.36	6.50	6.47	12.45	12.39
Potash	.45	.40	.28	.35	.18	.44	.34	.43	.32	.31	.32	.32
Soda	.26	.42	.14	.18	.45	.54	.42	.17	.28	.18	.16	.42
Lime	.69	.70	.65	.73	.61	.67	1.00	1.35	1.53	2.79	.92	.94
Magnesia	.38	.36	.77	.23	.65	.43	.25	.35	.65	.92	.24	.14
Iron (oxide)	2.93	3.05	3.23	2.39	2.99	3.78	2.83	2.90	2.52	2.72	3.05	3.65
Aluminia	3.19	4.63	4.35	5.68	5.52	7.75	5.75	6.15	4.26	3.98	5.75	6.15
Phosphates	.35	.26	.30	.22	.21	.20	.21	.23	.26	.33	.25	.25
Sulphates	06	.04	.24	.11	.70	.10	.06	.08	.02	.02	.09	.10
Carbonates	.55	.36	.52	.24	.55	1.35	.40	.11	.04	.70	.45	.94
Chlorides	.02	.02	.02	.01	.01	.01	.01	.01	.01	.02	.01	.01
Volatile	10.90	9.12	8.15	4.35	10.33	5.64	9.54	8.09	7.94	6.36	11.50	7.38
Total	98.85	99.89	99.54	99.97	99.44	99.88	99.28	99.83	99.10	99.67	98.96	99.75

Sample number 214 is from Benson, Swift county, it is not one of the typical prairie soils, but belongs more to that class of old "lake basin" soils. Both the top soil and the sub-soil are characteristically rich in limestone. These sub-soils are usually of a greyish color, and do not show the characteristic yellow color of most of the prairie sub-soils. These soils contain limestone to such an extent as to show a marked effervescence when treated with acids, and it can even be observed when strong vinegar is poured on them.

TABLE IV.

Where from	Worthington.		Benson.	
Top Soil and Sub-Soil Number of Soil	Top 326	Sub 327	Top 214	Sub 215
Weight per cubic foot	72.	75.	70.	72.
Fine Earth	100.	100.	100.	100.
Skeleton				
Humus	4.39		2.06	
Capacity to retain water	71.	45.	56.	51.
Total Nitrogen	.37	.01	.24	.07
Phosphates associated with Humus	.07		.05	
Insoluble Sand and Silicates	62.46	45.84	54.25	57.87
Combined Silica	12.22	15.97	8.13	8.04
Potash	.36	.22	.46	.20
Soda	.28	.44	.37	.32
Lime	1.06	11.33	13.56	12.08
Magnesia	.82	1.72	2.57	.27
Iron (oxide)	1.86	3.28	1.41	2.24
Aluminia	6.07	7.46	3.34	4.90
Phosphates	.65	.25	.27	.26
Sulphates	.21	.08	.04	.06
Carbonates	.37	10.94	10.40	9.82
Chlorides	.01	.01	.02	.02
Volatile	13.19	1.56	4.80	2.18
Total	99.56	99.10	99.62	98.23

SOIL SAMPLES FROM NORTHERN CENTRAL POINTS.

Soil sample number 208 is from Fergus Falls, Otter Tail county. It has produced ten crops of wheat. The top soil is a black loam, about twelve inches in depth, and shows the presence of a little sand. It has no tendency to cake and lump when dry. The top soil is a little weak in potash, but the sub-soil is sufficiently rich to make up for this want. The high phosphoric acid in the top soil, and such a liberal amount of it in available forms, speaks well for the future fertility of these soils. Soil sample number 292 is from Henning, the eastern portion of the same county. It was originally an oak and hard wood clearing, and has raised five crops of wheat. The top soil averages about fourteen inches in depth and then follows a yellow clay sub-soil that is richer in potash and phosphates. A somewhat larger per cent of lime is noted in the top soil; this is a point that appears quite general with the analysis of oak soils. Timothy is reported as thriving well on this soil, but quite frequently difficulty is reported in getting clover started. The surface soil appears to be the weakest in potash of any of the necessary minerals, and young clover requires a good supply of it to get started. Gypsum, will no doubt aid the clover in getting a start, and as soon as the clover roots reach down into the sub-soil then a liberal supply will be found.

Soil number 210 is from Alexandria, Douglas county, and has produced eight successive crops of wheat. This soil sample is selected because it is a good type of the sandy, gravelly sub-soils; it consists of about half fine gravel. Good clay sub-soils are equally as common in this locality. The top soil has a good supply of humus, and shows a correspondingly good capacity for retaining water. This land was originally a lumber tract, and is a black loam, sandy in character as is shown in the analysis.

Soil number 245 is from Wadena, Wadena county; it is a black sandy loam; has produced five successive crops of wheat. The soil particles are a little coarser than those from the south-western portion of the state. All of the soil particles are less than $\frac{1}{20}$th of an inch, and about twenty

per cent are less than 1/40th of an inch. Even in these soils of a slight sandy nature there is a good native stock of lime and phosphates; more so than is usually found in sandy loam soils. The top soil contains about three per cent more of organic matter in the form of humus than the sub-soil, and retains one-fifth more water in its pores.

Soil sample number 230 is from Park Rapids, Hubbard county. It is a black sandy soil of about two feet in depth, —the sub-soil is of a yellow sandy nature. The top soil contains about five per cent of combustible matter and humus, while the sub-soil contains only about a half of a per cent. The top soil and sub-soil particles are of about the same size. The top soil, which is about ten times richer in decaying vegetable matters, retains over two-thirds more water than the sub-soil. This soil shows the good effects of the humus and vegetable matters in retaining the water in the soil, as well as any other example that is reported in this work. This soil has produced five consecutive crops of wheat and according to some ideas and books, it would not be put down as a wheat producing soil; but notwithstanding this fact it has produced, and still continues to produce, good crops of wheat. The supply of humus and vegetable matter must be kept up in this soil.

Soil sample 273 is from Fair Haven, Stearns county; it was originally an oak clearing. The soil is six years old and has been treated to a good rotation of corn, oats, millet and wheat. The sub-soil is a yellow clay with some disposition to lump; it is not of a hard-pan nature nor impervious to water. The six years' rotation cultivation has left this soil in good condition, and as far as humus and nitrogen are concerned, compares favorably with the various examples of native soils that are reported.

TABLE V.—SOIL SAMPLES FROM NORTHERN CENTRAL POINTS.

Where from	Fergus Falls.		Alexandria.		Wadena.		Park Rapids.		Henning.		Fair Haven.	
Top Soil and Sub-Soil	Top	Sub	Top	Sub	Top	Sub	Top	Sub	Top	Sub	Top	Sub
Number of Soil	208	209	210	211	245	246	230	231	292	293	273	274
Weight per cubic foot	75.	85.	78.	88.	82.	86.	85.	88.	76.	82.	80.	84.
Fine Earth	90.	90.	87.	48.	100.	60.	95.	95.	97.	98.	96.	95.
Skeleton	10.	10.	13.	52.	.....	40.	5.	5.	3.	2.	4.	5.
Humus	2.68	.....	3.02	.....	3.02	.....	2.40	.....	3.89	.....	4.18	.....
Total Nitrogen	.24	.07	.24	.07	.25	.08	.15	.08	.26	.08	.39	.10
Capacity to retain water	49.	39.	50.	29.	50.	40.	41.	25.	48.	42.	43.	38.
Pposphates associated with Humus	.04	.....	.02	.....	.03	.....	.02	.....	.04	.....	.03	.....
Insoluble Sand and Silica	75.42	78.42	76.69	77.22	78.39	84.00	82.79	93.52	76.55	81.35	72.52	73.14
Combined Silica	8.51	7.31	5.64	7.62	5.97	5.10	6.34	3.12	5.88	7.43	10.56	11.63
Potash	.17	.45	.44	.24	.28	47	.26	.10	.19	.42	.20	.21
Soda	.09	.21	.13	.22	.24	.12	.26	.18	.18	.16	.19	.22
Lime	.54	.62	1.26	.72	.60	.25	.61	.31	.63	.31	.77	.40
Magnesia	.33	.42	.35	.64	.60	.37	.18	.07	.13	.11	.25	.34
Iron (oxide)	2.69	2.62	1.57	3.66	2.37	3.46	1.45	.67	2.39	2.82	2.96	3.76
Aluminia	3.60	2.80	3.38	4.39	3.14	2.30	1.61	.09	4.04	4.18	3.99	6.26
Phosphates	.32	.18	.31	.22	.20	.26	.15	.01	.36	.40	.21	.12
Sulphates	.06	.07	.09	.08	.02	.02	.09	.06	.10	.07	.09	.09
Carbonates	.06	.07	.81	.41	.03	.02	.01	.01	.04	.01	.10	.02
Chlorides	.02	.02	.02	.03	.....	.....	.02	.01	.01	.01	.01	.01
Volatile	7.13	5.48	7.60	4.19	7.09	3.63	5.99	.56	9.10	2.18	8.15	3.80
Total	98.94	98.67	98.29	99.61	98.93	100.	99.76	98.70	99.61	99.45	100.	100.

SOIL SAMPLES FROM NORTH-EASTERN MINNESOTA.

Soil sample number 216 is from Mille Lacs, and is a fair representative of the pine forest soils. This section has been occasionally burned over by forest fires, and hence the analysis does not show the full amount of humus and nitrogen that would otherwise be present in localities that have not been burned over, and where the leaves and dead branches have rotted and formed humus. Frequent and destructive forest fires will seriously decrease the agricultural value of these soils. The soil particles are extremely fine. There is a furrow slice of black top soil overlaying a yellowish sandy sub-soil that contain a very little true clay. This soil is a typical pine producing soil, and in appearance is quite like some of the pine soils from the Southern states. For comparison, an analysis is given, number 236, of an old pine soil from Tennessee. At the time this sample was analyzed it was supposed to be one from this state. When these two soils are placed side by side, they can not be distinguished by the eye or by mechanical analysis. The Tennessee pine soil has been cutivated about sixty years,and will not produce any more crops without fertilizers, while fertilizers have not as yet, come into general use on our cultivated pine soils. The pine soils will require careful farming, and the necessity of a good supply of humus in these soils, is, and will be, the most important want. There is comparatively more plant food in these soils than appears at first glance, because a cubic foot of these soils weighs nearly ninety pounds, as against seventy or seventy-five pounds for many other soils.

Soil sample number 228 is from Hinckley, Pine county. The top soil is a light yellowish red clay from one to two feet in depth. The sub-soil is a bright red clay, that becomes quite hard when dried in the air. The top soil does not lump so badly. These sub-soils contain a high per cent of iron oxide from four to five pounds of it in every hundred pounds of the soil. There is no iron present in the ferrous forms, and hence this large amount is in a perfectly harmless form and will not injure the roots of plants. A very little

additional organic matter in these soils improves them to a great extent, especially as regards the ease with which they are worked. The potash reported in the tables for these soils is only the potash that is present in easily soluble forms. There is, all told, from two and a half to three pounds of potash in every hundred pounds of these soils, and as yet we have not sufficient data to determine how much becomes available each year by good cultivation for crop purposes. The evidence appears to be that there is quite a large amount because such large yields of potatoes and root crops are annually raised on these soils without any application of potash fertilizers.

In some small localities, the clay sub-soil gives way to a layer of greyish deposit. This is found particularly in low places. A number of samples of this material have been received at the laboratory. This material is marl and is composed mainly of lime stone with a small amount of clay. On some soils this marl will no doubt do some good when used as a fertilizer, but it will not pay to haul it any great distance. It will probably be found to do the most good on the soils of a sandy character, and will improve the working condition of some of the heavy clay soils. The analysis of the marl reported is from Rush City.

Soil sample number 232 is from New Duluth, St. Louis county. The top soil is well supplied with phosphates, lime and magnesia. The sub-soil is very rich is potash but only about a tenth of it is "unlocked." This soil has been cultivated fifteen years.

Soil number 264 is from Duluth. It is bright red in color with quite a few small gravel stones mixed with it as is indicated in the mechanical analyis. This section joins the city limits on the north side; it has raised one crop of potatoes.

Soil number 212 is from St. Cloud; it is a fine black sandy soil, one of the typical potato soils of that region. It has raised fifteen crops and has been well manured. There is an unsually high content of potash present for these soils.

Sample 288 is from Wyanette, Isanti county. It is a dark sandy soil seven to eight inches in depth overlaying a yellowish sandy sub-soil; it has been cultivated for two years.

TABLE VI.—SOIL SAMPLES FROM NORTH-EASTERN POINTS.

Where from	Mille Lacs.	Pine.	Hinckley.		New Duluth.		Wyanette.		St. Cloud.		Duluth.	Marl.
Top Soil and Sub-Soil	Top	Top	Top	Sub	Top	Sub	Top	Sub	Top	Sub	Top	Sub
Number of Soil	216	236	228	229	232	233	288	289	212	213	264	244
Weight per cubic foot	86.	88.	86.	90.	89.	95.	80.	88.	74.	84.	80.	.....
Fine Earth	100.	100.	95.	92.	96.	98.	100.	99.	98	94.	88.	
Skeleton	.....	.....	5.	8.	4.	2.	.....	1.	2.	6.	12.	.....
Humus	.65	.60	1.69	.....	1.77	.....	1.10	.....	3.24	.....	.89	
Capacity to retain water	38.	40.	53.	34.	42.	46.	41.	34.	46.	34.	46.	.....
Total Nitrogen	.07	.05	.12	.01	.09	.01	.15	.05	.17	.12	.08	
Phosphates associated with Humus	.01	.....	.03	.....	.01	.....	.02	.....	.03	.....	.01	.....
Insoluble Silicates and Sand	89.80	86.07	76.35	63.35	79.03	64.18	89.50	91.32	83.27	84.72	71.13	12.82
Combined Silica	2.62	2.64	10.76	16.55	9.88	15.07	3.47	2.92	5.44	3.35	7.61	.....
Potash	.14	.08	.18	.20	.27	.21	.08	.08	.85	.62	.25	.12
Soda	.34	.04	.20	.40	.16	18	.08	.18	.35	.35	.36	.06
Lime	.38	.11	.76	.22	.32	.85	.21	.22	.26	.38	.51	38.32
Magnesia	.29	.12	.25	.27	.51	1.04	.13	.20	.10	.38	.12	.72
Iron (oxide)	1.15	1.32	3.55	4.71	1.02	5.90	1.34	1.66	1.66	1 79	5.35	1.25
Aluminia	3.02	3.63	5.73	5.56	3.30	8.55	1.86	1.79	2.22	3.95	5.03	2.01
Phosphates	.22	.04	.12	.36	.33	.08	.10	.13	.19	.15	.45	.35
Sulphates	.10	.07	.06	.13	.02	.02	.10	.07	.09	.06	.03	.34
Carbonates	.05	.25	.01	.03	.38	.45	.02	.03	.07	.04	.04	.01
Chlorides	.01	.01	.01	.02	.01	.01	.01	.01	.03	.04	.02	40.10
Volatile	1.56	3.85	2.00	8.00	3.90	2.94	2.98	1.31	5.12	4.05	8.47	4.09
Total	99.69	98.21	99.98	99.80	99.13	99.48	99.88	99.92	99.65	99.88	99.47	.....

Soil from the Experiment Station.—In passing from the Central Eastern points to the soils of the South-Eastern portion of the state, a few words can be said in regard to the composition of the experiment station soil, and particularly as to the effects of heavy applications of well prepared manures during dry seasons. The experiment station is located between the two sections noted above.

The effects of heavy manuring was clearly shown during the season of 1893. A pile of well rotted mixed manure was drawn out in a field that had raised a corn crop the previous year. The well rotted manure was spread very heavy. A prominent knoll was left with one-half heavily manured, and the other half without any. About the last of June an unusually dry time set in. Previous to this, the corn on this knoll appeared to be all about alike, the manure hardly showed itself, but as soon as the dry spell came the manured part kept on growing without showing the effects of the drought to any great extent while the unmanured part made very little progress. The soil on this knoll was sandy and porous, and on the unmanured half it dried out badly, while on the other half a perceptible amount of water remained.

Samples of the soil from each lot were taken to the laboratory on June 30, and the amount of water determined. There was an average of twelve and one half per cent of water in the first six inches of soil in the heavily manured plot, and eight and nine-tenth per cent in the unmanured plot. July 23 there was ten and one half per cent in the manured part and eight and one-tenth in the unmanured part. At one time after two days of hot dry winds the soil water in the unmanured part reached as low as seven per cent, while the manured part never reached below ten per cent. At harvest time the fodder corn on the manured part was on an average two feet taller than the corn on the unmanured part. This was not due so much to the absence of fertility in the soil of the unmanured part as it was to the want of the proper amount of moisture. The greatest value of well prepared farm manures is in furnishing humus and keeping the soil from drying out. In order to be of full benefit the manure must be well rotted before spreading on the land, otherwise in a dry season there is not sufficient moisture in the soil to rot the straw that is in the manure,—it is then plowed under and not infrequently lays in the soil for two or three years before rotting, and causes the soil to dry out more, by being open loose and porous than it otherwise would if this coarse manure were not present. Straw is not manure until it i

well rotted. The beneficial effects of well rotted manures in aiding the soil to retain its water, is noted and discussed in connection with some of the soils from South Eastern Minnesota.

A detailed discussion of the composition of the soils from the Experiment Station farm is not given. One analysis is reported, number 241. A number of analyses have been made in connection with plot experiments and the draft of different crops upon the soil, as well as different methods of rotation. The work has not, as yet, been carried on a sufficient length of time to obtain definite results, but sufficiently encouraging results have already been obtained to warrant a continuation of the work.

There are some points as to the general composition of the sample soil (No. 241) that can be noted. The top soil is a black loam, with a sandy nature in some portions of the farm, and clayey in other portions. The sub-soil is a yellow clay; the top soil, when perfectly dry, weighs about seventy-three pounds per cubic foot, and has a fair content of potash, lime and phosphates. The nitrogen is not as high as in the virgin soils, yet nitrogen fertilizers do not appear to be particularly beneficial, nor do potassium preparations show any good results. The top soil will retain more water and for a longer time than the sub-soil. The presence of only a very little sand will cause it to dry out until the first three or four inches is in nearly an air dry condition.

SOILS FROM SOUTH-EASTERN MINNESOTA.

Samples number 277 and 279 are from Farmington, Dakota county. Both were originally native prairie soils and have been under cultivation for thirty-five years. Number 277 has been under high cultivation, received regular and liberal dressings of manure, and raised good crops of corn, oats, wheat and grass.

In another and an adjoining field, that originally raised as heavy crops, sample number 279 was taken. This field has been under cultivation for the same length of time, thirty-five years, has never received any manure, nor been summer fallowed. It has always produced a grain crop, but for the past few years the yield has been unusually low, and during droughty seasons it suffers much more than the adjoining field that has been rotated and well manured.

From the analysis it will be observed that the main differences are in the amounts of humus, sand and nitrogen that are present. The well manured and more productive soil yielded 3.32 per cent humus and .30 per cent nitrogen, against 1.80 per cent humus and .16 per cent nitrogen in the poorer soil. There is the same amount of phosphoric acid in each soil, .20 of a per cent, which would ordinarily be considered a very large amount, but in the poorer soil there is only .01 of a per cent that is associated with humus in available forms, while in the well manured soil there is .04 of a per cent available. The amount of potash as given in the analysis is practically the same for each with a shade of advantage in favor of the better soil, and yet larger quantities of potash have been annually removed in the more productive soil. The total amount in each soil is 1.42 per cent for the manured soil and 1.50 per cent for the poorer soil. There is evidence that the thorough cultivation of the one soil has materially aided in rendering a portion of this insoluble potash available as plant food. The total insoluble matters (sand, silicates, and combined silicates) are about the same in each, when they are compared on an equal footing as to humus. In the case of the better soil, however, there is nearly seven per cent of silica that is combined with

the potash, soda, aluminia and lime, while in the poorer soil there is only four per cent in this form. The thorough cultivation of the one soil has without doubt been the chief cause of the decomposition, and breaking up, of this three per cent of stony particles. Plant food can be cultivated into available forms cheaper than it can be purchased.

The history of these two fields, as to their former similarity in every way, their original alike productiveness compared with their present dissimilarity and unlike productiveness, together with the different methods of cultivation that have been the cause of the decline in fertility, and finally their present comparative composition after thirty-five years unlike treatment, are facts that should be carefully considered because they emphatically suggest the necessity of keeping up the organic matter in the soil, coupled with a judicious system of rotating crops.

Sample number 239 is from Rolling Stone, Winona county. It has been under cultivation for forty years and has produced good crops of wheat, corn, barley and oats. For the last twelve years a rotation of corn, barley and oats has been practiced. It is bottom land and has been well kept up by manure; the nitrogen, humus and other points speak well for the land as not suffering from cropping. There is a good content of phosphoric acid present, and a good working supply of potash. The silicates and stony particles appear to be easily decomposed.

Sample number 281 is from Faribault, Rice county. It has been under cultivation for thirty-eight years; the first fourteen years it always produced a grain crop of some kind. It produced hay for two years, was pastured one year, and for the past ten years has produced corn, oats and wheat in rotation. It has occasionally received a dressing of manure, and has never been summer fallowed. The land is in good condition, and the analysis does not indicate any weak points; however, it will not do to allow the humus to reach much below the present point.

Sample number 283 is from Owatonna, Steel county. It was originally a timber tract and has been cultivated for thirty-five years. The land has been well cultivated and occasionally manured, and for the past seven years has produced three crops of corn, three of clover, and one of oats. The soil is in good condition with reasonable working amounts of all of the necessary plant food compounds. The clover appears to have left its mark in a good nitrogen content.

TABLE VII.—SOILS FROM SOUTH-EASTERN MINNESOTA.

Where from	Farmington.		Farmington.		Rolling Stone.		Faribault.		Owatonna.		Ex. Station.	
Top Soil and Sub-Soil	Top	Sub	Top	Sub	Top	Sub	Top	Sub	Top	Sub	Top	Sub
Number of Soil	277	278	279	280	239	240	280	281	283	284	242	243
Weight per cubic foot	70.	74.	72.	74.	74.	79.	76.	77.	86.	87.	76.	78.
Fine Earth	96.	95.	96.	95.	97.	98.	88.	83.	95.	93.	94.	97.
Skeleton	4.	5.	4.	5.	3.	2.	12.	17.	5.	7.	6.	3.
Humus	3.32	.....	1.80	.....	3.49	.....	2.80	.....	2.66	.....	2.41	.....
Total Nitrogen	.30	.21	.16	.17	.25	.....	.24	.08	.26	.....	.21	.11
Capacity to retain water	48.	46.	39.	46.	49.	46.	41.	34.	47.	39.	53.	51.
Phosphates associated with Humus	.04	.....	.01	.....	.03	.....	.02	.....	.30	.....	.02	.....
Insoluble Silicates and Sand	74.43	74.05	78.32	73.79	71.89	74.81	80.06	79.73	83.25	82.16	73.67	73.51
Combined Silica	6.93	8.46	4.01	9.36	8.85	8.94	6.04	7.07	5.39	7.32	10.41	11.04
Potash	.20	.22	.19	.20	.30	.20	.23	.21	.23	.26	.30	.18
Soda	.19	.16	.16	.13	.23	.32	.18	16	.13	.12	.25	.21
Lime	.46	.51	.48	.35	.41	.40	.54	.50	48	.48	.51	.34
Magnesia	.18	.22	.27	.35	.39	59	.30	.41	.18	.29	.26	.29
Iron (oxide)	2.60	3.27	2.88	3.22	3.01	4.17	2.29	3.06	2.09	1.99	2.56	3.40
Aluminia	4.43	5.44	4.80	4.34	4.63	4.59	3.94	4.58	2.75	2.91	4.24	5.61
Phosphates	.20	.16	.20	.16	.23	.18	.21	.15	.13	12	.23	.21
Sulphates	.15	.12	.12	.15	.04	.03	.08	.05	.09	.08	.06	.08
Carbonates	.09	.09	.09	.08	.12	.11	.09	.09	.13	.09	.29	.02
Chlorides	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
Volatile	9.40	7.29	8.31	6.21	9.81	5.47	5.93	3.85	5.00	4.26	7.04	4.37
Total	99.27	100.	99.84	98.35	99.92	99.82	99.90	99.95	99.86	100.09	99.83	99 27

Sample number 218 is from Austin, Mower county. It is a typical example of a new soil; it is a "Jack oak" clearing and has raised three crops of corn and two of wheat. This soil has a good stock of native fertility and will wear well. It is particularly rich in phosphoric acid, and a fair portion of it is in soluble forms.

The sample from Wells, Faribault county, number 220, is one of the same class of soils, an oak clearing, three years old; corn was grown the first year, and wheat during the two following years. The soil is liberally supplied with plant food; the high per cent of humus—4.17, is noticeable and is a characteristic of the new soils, but unfortunately it does not last very long.

An analysis is given, number 294, of a soil that has been a permanent meadow for about thirty-five years, and produced large crops of native hay; but "during the past ten years bare spots have appeared that have refused to grow any kind of grass; timothy, clover and red top have been tried on these spots but without success and the spots are yearly increasing in size." The soil consists largely (over seventy per cent) of decaying vegetable and other organic matters. It contains a very small amount of mineral matter, less than seven pounds per cubic foot, while many soils contain as high as seventy pounds of mineral matter per cubic foot. There are no other forms of potash present except the .19 of a per cent reported, and the large drafts of the grass crops have told the heaviest on this material. A good application of unleached wood ashes will do the most good for these spots. This tract was originally a marshy place, but by draining it was made to produce good crops of grass, and it is, like many other reclaimed places, the main source of supply of the hay crop. The sub-soil is quite rich in lime and gypsum which prevents the formation of sour mould. The sub-soil is very rich in phosphates, and altogether it is too valuable to be used only as a meadow. There is an unusual amount of fertility in many of these low and marshy places, which, if reclaimed, will prove to be very fertile soils.

TABLE VIII.

Where from / Kind of Soil	Austin. Oak Clearing.		Wells. Oak Clearing.		Mankato. Permanent Meadow.	
Top Soil and Sub-Soil / Number of Soil	Top 218	Sub 219	Top 220	Sub 221	Top 294	Sub 295
Weight per cubic foot	68.	76.	75.	79.	25.	42.
Fine Earth	98.	99.	97.	98.	.....	.....
Skeleton	2.	1.	3.	2.	.....	.....
Humus	3.73	.....	4.17	.....	.24	.14
Capacity to retain water	57.	47.	68.	49.	125.	68.
Total Nitrogen	.30	.15	.37	.20	1.29	.14
Phosphates associated with humus	.04	.....	.04	.....	.04	.....
Insoluble Silicates and Sand	71.19	75.05	66.15	68.79	15.81	31.63
Combined Silica	11.09	9.17	11.49	12.81	2.66	6.58
Potash	.32	.08	.36	.30	.19	.17
Soda	.34	.31	.41	.35	.18	.20
Lime	.48	.21	1.10	.80	.53	4.16
Magnesia	.45	.61	.99	.68	.11	.20
Iron (oxide)	2.81	3.26	2.40	2.68	2.62	5.99
Aluminia	4.77	4.44	3.61	5.92	1.38	4.48
Phosphates	.38	.30	.25	.24	.30	.60
Sulphates	.15	.10	.16	.16	1.66	2.09
Carbonates	1.40	1.43	.56	.75	1.67	3.19
Chlorides	.01	.01	.01	.01	.01	.01
Volatile	6.56	5.00	12.40	6.50	72.80	39.92
Total	99.95	99.97	99.89	99.99	99.92	99.22

SUMMARY.

1. The continued cropping of soils to grain crops only without any system of rotation, or other treatment is telling severely upon the original stock of half decomposed animal and vegetable matters, and nitrogen. Soils which have produced grain crops, exclusively, for ten or fifteen years contain from a third to a half less humus and nitrogen than adjoining soils that have never been plowed.

2. Soils which have been cropped until the organic matters and humus have been materially decreased, retain less water and dry out more readily than when there is a larger amount of organic matter present in the soil.

3. Soils which are rich in humus contain a larger amount of phosphates associated with them in available forms than the soils that are poor in humus.

4. Soils which are rich in humus and organic matters produce a larger amount of carbon dioxide that acts as a solvent upon the soil particles and aids the roots in procuring food.

5. One half of a sandy knoll, heavily manured with well rotted manure, contained nearly a quarter more water during a six week's drought, than the other half that received no manure.

6. The supply of organic matter in the soil must be kept up because it takes such an important part, indirectly, in keeping up the fertility of the soil. A good system of rotation, including sod crops, and well prepared farm manures will do this, and will avoid the introduction and use of commercial fertilizers which are now costing the farmers of the United States over thirty-five million dollars annually. It will not do to wait until this question forces itself upon us.

7. A rotation of crops will soon be necessary on account of the peculiar composition of some of the soils and the corresponding subsoils, especially those in which the surface soils are richer in phosphates and nitrogen while the subsoils are richer in potash and lime. By means of rotation the full benefits of the strong points of both the top soils and the subsoil will be secured.

NOTE IN REGARD TO SOIL ANALYSIS AND SENDING SAMPLES.

The original act that created experiment stations designated soil analysis and soil work as one of the important lines of investigations to be undertaken by the stations. This work has not been pushed by most of the stations as vigorously as many other lines; this has not been on account of any desire not to do a full amount of soil work, but many have questioned whether a soil analysis is justifiable because of its not telling more, and on account of the various difficulties that are connected with soil analysis; but this is no excuse for not attempting to find out more. A knowledge of the chemistry and the related physics of our soils will indicate the ways to better methods of rotations, the production and application of manures, and in an intelligent application of fertilizers when that time comes. Such knowledge, it is hoped, will throw light on many related questions as to methods of cultivation, depth and time for plowing, the use of green manures, etc., so as to retain the present fertility of our soils.

Before sending samples for analysis, you are requested to first write to the Experiment Station for directions for taking the samples of soil. It will not do to go out into a field and take a small sample at random. A blank will be sent with the directions asking the exact location of the plot, section township, range, etc., and the previous history of the cultivation of the soil, crops produced, etc. All this is necessary, not so much for present purposes as for future use,—in case anyone desires to go to these same places again after a number of years farther cultivation, and obtain a sample in order to see just what the changes have been.

All express charges on the soil sample must be prepaid; this is to insure protection against generous sized unpaid packages of soil. The analysis will be made free of charge. Only a limited number of analyses can be made and it is the aim, that these should represent as many soils, sections, and conditions as possible. Some idea of the labor involved will be gained from the fact that the first operation in soil analysis requires five days in order to get the different materials dissolved, while as many more days are required for their separate determination. The analyses are made in sets of six or eight. When the sample is received at the laboratory it will be acknowledged. Do not expect a report in too short a time, because there are always soil samples waiting to be analyzed, as well as other work waiting to be done, but as soon as the analysis is completed a report will be sent to you.

University of Minnesota.

Agricultural Experiment Station.

BULLETIN No. 31.

AGRICULTURAL DIVISION.

December, 1893.

Lambs Practical Rations for—Also Lambs vs. Wethers, for Fattening—Valuation of Wheat Screenings—Field Experiments—Varieties of Wheat, Oats and Corn—Methods of Planting Oats, Wheat and Potatoes—Depth to Sow Oats and Wheat, and Time to Sow—Heavy vs. Light Oats for Seed—Methods of Preparing Land for Oats.

☞ The Bulletins of this Station are mailed free to all residents of the State who make application for them.

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Minneapolis:
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LAMBS—PRACTICAL RATIONS FOR;

ALSO

LAMBS VS. WETHERS, FOR FATTENING.

W. M. HAYS.

During the winter of 1891-2 an experiment was conducted in feeding sheep under the supervision of the present writer. As he was absent from the Station during the latter half of the feeding, the last part of the work was superintended by Mr. Andrew Boss, foreman of the farm, while the feeding was done by herdsman Wm. Gibbs. Eighty Shropshire grade half-blood lambs were purchased in December of Mr. E. M. Prouty, of Grand Forks, N. D., at 5 cents per pound. These were divided into eight groups of ten, each very uniform in weight, averaging about 735 pounds. Ten fair average Montana wethers were also purchased at the same time at $4.20 per 100 pounds; these averaged 107 pounds each. The object of the experiment was to compare several of our most practical grains, when fed with timothy hay, in fattening lambs; also to get at the comparative profit of feeding grade lambs and western wethers. The rations were so constructed that we might determine the value of the addition of a limited amount of oil cake to a grain ration of corn or of barley (see pens 2 and 4 in comparison with pens 1 and 3 in table VII.) These grains were compared with wheat screenings (see pen 8.) By securing screenings composed mainly of small wheat, pen 5; another lot of nearly pure wild buckwheat, pen 6, and another of nearly pure pigeon grass seed, pen 7, the value of these three most prominent ingredients of screenings were compared with the ordinary screenings composed of a mixture of these three ingredients together with minor amounts of other weed seeds, chaff, etc. The screenings fed (pen 8) were selected as an average of the screenings offered in the Minneapolis market. (See

analyses in table I.) The analyses of the other grains are also given in table I. The wethers (pen 9) were fed screenings and hay in the same manner as the lambs in pen 8 were fed these two foods.

The plan of the experiment was to give timothy hay ad-libitum in self feeding racks and allow the sheep access to the self-feeding grain boxes two hours in the morning and two hours in the evening during the first period. The second period they were to be allowed to run to the open self-feeding grain boxes or troughs all the time and all pens were to have the same limited amount of hay, that the effect of the grain rations might be compared in the different groups. This plan for the second period was slightly modified by allowing all the groups access to the hay the same limited time each day—two hours at midday. This makes the comparison of the grain rations a little more difficult, but was the more practical way to feed, and the comparison of ration with ration as to net profit is all the more practical.

The sheep were placed under the Station barn in a shed which was open on one entire side into a large alley, which in turn was open to the free entrance of outside air, thus making uniform conditions for all pens. The groups were separated by hurdle-like fences, each group having a pen about 10 by 16 feet, and were all very similarly situated and fed and watered and salted alike. The lambs were, withal, a very even, thrifty lot of sheep, as shown by their appearance and by their profitable gains.

The groups of lambs in pens 5, 6 and 7 were fed with a view to gaining a knowledge of how to estimate the value of any given sample of wheat screening by getting at the comparative value of the several most prominent ingredients. These pens were accordingly given respectively screenings composed almost entirely of small wheat, wild buckwheat seed and pigeon grass seed. As the results indicate these three main constituents of screenings to be of about equal value, and nearly equal to corn for feeding sheep, it is easy to estimate the value of any sample of screenings by determining the percentage of solid grains and of ground particles of grains contained. As straw and other coarse roughage on the farm is

very cheap not much value is attached to the chaff, pieces of straw and similar parts of the screenings. Where feeders must purchase straw and hay they can count these "light parts" of the screenings as of equal value to straw or coarse hay of rather poor quality. Where a sample contains mustard, pig weed seeds or other bitter weed seeds which are not relished by the animals, something must be subtracted from the estimated value. The presence of weed seeds which might gain an entrance to the farm is a great objection to the use of many samples of screenings, as some uneaten seeds will be scattered in the manure. Where it can be done all screenings fed to cattle, hogs or horses should first be run through a roller mill, with rollers kept sharp, that as many as possible of the weed seeds may be broken so that the digestive juices can get through the hard seed coatings, both to enable the animal to get the nourishment and to kill the weed seeds which might otherwise grow after passing through the animal. It is often wise or necessary to systematically compost all manure from animals fed screenings that the weed seeds may all be germinated and thus destroyed. Since screenings are such valuable foods and contain also such a large manurial value it is to be regretted that our system of marketing grains does not encourage or even make it necessary for farmers to keep all the screenings at home for feed and manure and take to market only grain entirely cleaned of weed seeds. A change in our manner of grading or inspecting grain throughout the entire country should be so made as to encourage marketing only well cleaned grain.

Screenings from the large mills are each year becoming poorer in quality as the manufacturers of flour constantly improve their means of separating out and utilizing the small kernels and pieces of wheat. Some of the machinery used in this separation of the small wheat crushes or grinds part of the weed seeds, and the screenings appear to be made up in part of floury particles.

No credit is given in this report for the value of the manure made of the several grain feeds consumed. Allowance for the manurial value would show the feeding even more profitable than the tables now represent.

TABLE I.—Analysis of Grains Fed.

	Total dry matter.	Ash.	Total nitrogen compd.	True albuminoids.	Fat.	Crude fiber.	Nitrogen free extract	‡Prices per ton.
Corn	89.27	1.46	10.25	9.60	3.88	2.25	70.40	$13.04
Barley	88.22	3.32	11.57	10.92	2.70	3.00	67.63	17.50
*Oil meal, O. P.	90.80	5.70	32.90	.....	7.90	8.90	35.40	27.87
Screenings composed of small wheat.	90.05	2.24	13.81	.....	2.90	4.25	66.85	10.56
Screenings composed of wild buckwheat	88.08	2.65	10.62	8.42	3.25	10.77	60.81	10.56
Screenings composed of pigeon grass seed	89.35	5.18	9.48	.....	5.50	15.15	54.52	10 56
†Screenings	87.50	2.69	11.84	.....	3.10	4.76	65.09	10.56
‡Timothy hay	.....	.....	.....	.....	.....	.....	.....	7.13

The corn, barley, wild buckwheat and pigeon grass seeds were anylyzed by Prof. Harry Snyder.

*Average from Hand Book of Experiment Station Work.

†Average from Bulletin No. 8, Minnesota Experiment Station.

‡The prices given here per ton are averages of reports made by many farmers during the winter of 1891-2.

TABLE II.—Food Eaten and Gains in First Period of Eight Weeks.

No. of pen.	Kind of Sheep.	Kind of grain fed.	Weight of sheep at beginning.	Weight at ending.	Gain in weight.	Hay eaten.	Grain eaten.
1	Lambs	Cracked corn	710	875	165	657	740
2	"	9-10 cracked corn... 1-10 oil meal	722	945	223	485	984
3	"	Barley	733	902	169	485	864
4	"	9-10 barley 1-10 oil meal	757	946	189	449	1,088
5	"	Small wheat	737	905	168	560	1,043
6	"	Wild buckwheat	754	909	155	441	1,121
7	"	Pigeon grass	741	864	123	344	1,244
8	"	Screenings of wheat	736	862	126	498	1,138
9	Wethers	Screenings of wheat	1,068	1,173	105	447	1,404

TABLE III.—Food Eaten and Gains in Second Period of Four Weeks.

No. of pen.	Kind of Sheep.	Kind of grain fed.	Weight of sheep at beginning.	Weight at ending.	Gain in weight.	Hay eaten.	Grain eaten.
1	Lambs	Cracked corn	875	921	46	192	363
2	"	9-10 cracked corn... 1-10 oil meal	945	1,011	66	149	443
3	"	Barley	902	932	30	145	404
4	"	9-10 barley 1-10 oil meal	946	1,031	85	154	503
5	"	Small wheat	905	939	34	182	462
6	"	Wild buckwheat	909	991	82	150	813
7	"	Pigeon grass seed	864	967	103	83	731
8	"	Screenings of wheat	862	980	118	111	638
9	Wethers	Screenings of wheat	1,173	1,240	67	95	706

TABLE IV.—Food Eaten and Gains During Entire Twelve Weeks.

No. of pen.	Kind of Sheep.	Kind of grain fed.	Weight of sheep at beginning.	Weight at ending.	Gain in weight.	Hay eaten.	Grain eaten.
1	Lambs....	Cracked corn.....	710	921	211	849	1,103
2	"	9-10 cracked corn.... 1-10 oil meal	722	1,011	289	634	1,427
3	"	Barley	733	932	199	630	1,268
4	"	9-10 barley..... 1-10 oil meal.....	757	1,031	274	603	1,591
5	"	Small wheat.....	737	939	202	742	1,505
6	"	Wild buckwheat	754	991	237	591	1,934
7	"	Pigeon grass seed.....	741	967	226	427	1,975
8	"	Screenings of wheat...	736	980	244	609	1,776
9	Wethers..	Screenings of wheat...	1,068	1,240	172	542	2,110

TABLE V.—Value of Foods and of Gains and Profits in Period I.

	Kind of Sheep.	Grain fed with hay.	Value of hay fed.	Value of grain fed.	Total cost of food.	Value of Increase in weight.	Profit or loss on gain in weight alone.
1	Lambs....	Cracked corn	$2.22	$4.82	$ 7.04	$9.90	+$2.86
2	"	9-10 cracked corn..... 1-10 oil meal.....	1.64	7.14	8.78	13 38	+4.60
3	"	Barley.....	1.64	6.39	8.03	10.14	+2.11
4	"	9-10 barley..... 1-10 oil meal..... ...	1.52	8.76	10.28	11.34	+1.06
5	"	Small wheat.....	1.89	5.51	7.40	10.08	+2.68
6	"	Wild buckwheat.....	1.49	5.92	7.41	9.30	+1.89
7	"	Pigeon grass.....	1.16	6.56	7.72	7.38	—.34
8	"	Screenings of wheat....	1.68	6.00	7.68	7.56	—.12
9	Wethers...	Screenings of wheat....	1.51	7.41	8.92	5.25	—3.04

TABLE VI.—Value of Foods and of Gains and Profits in Period II.

	Kind of sheep.	Grain fed with hay.	Value of hay fed.	Value of grain fed.	Total cost of food.	Value of Increase in weight.	Profit or loss on gain in weight alone.
1	Lambs....	Cracked corn	$.65	$2.37	$3.02	$2.76	$— .26
2	"	9-10 cracked corn..... 1-10 oil meal.....	.50	3.20	3.70	3.96	+ .26
3	" ...	Barley.....	.49	2.99	3.48	1 80	—1.68
4	"	9-10 barley..... ..... 1-10 oil meal.....	.52	3.98	4.50	5.10	+ .60
5	"	Small wheat.....	.62	2.44	3.06	2.04	—1.02
6	"	Wild buckwheat.....	.51	4.29	4.80	4.92	+ .12
7	"	Pigeon grass.....	.28	3.86	4.14	6.18	+2.04
8	"	Screenings of wheat....	.38	3.37	3.75	7.08	+4.33
9	Wethers...	Screenings of wheat....	.32	3.72	4.04	3.35	— .69

TABLE VII.—Financial Results for Entire Period of Twelve Weeks.

1	2. Kind of Sheep—10 in each pen.	3 Grain fed with Hay.	4 *Value of hay fed.	5 Value of grain fed.	6 Total cost of food.	7 Value of increase in weight.	8 Profit or loss on Increase.	9 Increased value of original weight.	10 Total increase in value	11 Total profit.	12 Prices paid for grain per ton.	13 Received from grain, eliminating hay at cost.	14 Proportion'te prices rec'd per ton for grain.
1	Lambs....	Cracked corn.....	$2.87	$ 7.19	$10.06	$12.66	+$2 60	$7.10	$19.76	$ 9.70	$13.04	$16.89	$25.60
2	" ..	*9-10 cracked corn, 1-10 oil meal	2.14	10.34	12.48	17.34	+ 4.86	7.22	24.56	12.08	14.52	22.42	28.52
3	"	Barley.....	2.13	9.38	11.51	11.94	+ .43	7.33	19.27	7 76	14.80	17.14	24.77
4	" ...	9-10 barley, 1-10 oil meal	2.04	12.74	14.78	16.44	+ 1.66	7.57	24.01	9.23	16.11	21.97	25.01
5	" ...	Small wheat.....	2.51	7.95	10.46	12.12	+ 1.66	7.37	19 49	9.03	10.56	16 98	19.66
6	"	Wild buckwheat.....	2.00	10.21	12.21	14.22	+ 2.01	7.54	21.76	9.55	10.56	19.76	18.81
7	" ...	Pigeon grass.....	1.44	10.42	11.86	13.56	+ 1.70	7.41	20.97	9.11	10.56	19.53	18.65
8	"	Screenings of wheat.....	2.06	9.37	11 43	14.64	+ 3.21	7.36	22.00	10.57	10.56	19.94	20.32
9	Wethers...	Screenings of wheat.....	1.83	11.13	12.96	8.60	+ 4.36	8.54	17.14	4.18	10.56	15.31	14.04

*The average price of $7.13 per ton for hay, as compiled from statistics received from farmers, was used for calculating the cost of the hay; and $27.87 was used in calculating the cost of the oil meal.

In column 13 the figures represent the total value received minus the cost of the hay fed. at $7.13 per ton. In column 14 the figures represent the price realized from the different grain rations when the profits are apportioned on hay and grain in proportion to the cost of the amount of each fed.

SUMMARY

(1.) Corn fed with hay produced 20 cents profit per lamb more than barley fed with hay, when corn was valued at $13.04, barley $14.52 and hay $7 per ton, average prices throughout the State at that time.

(2.) When one-tenth oil meal, costing $27.87 per ton, was added to the grain, the lambs fed corn with hay produced 27 cents profit more each than those fed barley, oil meal and hay.

(3.) Rating the profits proportionately on grain and hay according to the cost of the amounts of each fed, the corn fed with hay produced 80 cents per ton more than the barley when fed to lambs.

(4.) When both were thus fed and with an addition of one-tenth oil meal, about two dollars more per ton was received for the corn than for the barley.

(5.) With the corn worth $13 per ton, or 36½ cents per bushel, the barley was worth, as shown by the lambs, $12.30 per ton or 29½ cents ber bushel; the "screenings" (90 per cent. small wheat grains and edible weed seeds,) about $10.35 per ton; the small wheat (90 per cent small, shrunken wheat,) $10 per ton; the wild buckwheat (90 per cent. wild buckwheat,) $9.56 per ton; and the pigeon grass seed (90 per cent. pigeon grass seed) $9.40 per ton.

(6.) The feeding value per ton for sheep may be calculated with fair accuracy by first determining the total percentage of grains of wheat, oats, barley, and edible weed seeds, and floury particles of such grains and seeds, and give this three-fourths the value of corn or barley at ruling prices. If there are present enough mustard, pig-weed or other bitter weed seeds to make the flavor decidedly bad a less valuation must be made on account of less feeding value. Seeds of noxious weeds also count against the value of the sample as the manure will scatter them on the farm unless especial care be used. The straw, chaff, pieces of weeds and other similar materials forming a larger or smaller part of the screenings have little value on the farm where roughage is very cheap and hardly need be taken into account.

(7.) It paid well to feed one-tenth oil meal in the grain ration, both when feeding corn and when feeding barley.

(8.) The pens of lambs which made the most clear profits in increased value above cost of grain and hay at prices named in table, were those fed cracked corn with one-tenth oil meal and those given a fairly good sample of wheat screenings. The pen-fed barley gave the least profits per head.

(9.) While grade Shropshire lambs purchased at five cents per pound in the fall, and fed hay and screenings, and sold at six cents in the spring—made a profit of $1.05 each, western two years old wethers (evidently grade merinos) bought at $4.20 per hundred, and sold in the spring at five cents per pound, gave a profit of only 40 cents each. The lambs got a half more of value per ton out of the food they consumed than the wethers.

FIELD EXPERIMENTS IN 1893.

ANDREW BOSS.

The reports herewith of varieties of field crops, of tests of machinery and methods of cultivation, of depths of planting crops, time of seeding, and of heavy vs. light seed grain, are of work done during 1893 by the writer. Prof. C. D. Smith, then the director of the station, assisted in planning the most of these experiments. Much of the work of the season is reserved for duplication and further study.

VARIETIES OF WHEAT.

The following varieties of wheat were raised on the University Farm during the season of 1893 on a mixed clay and loam soil that had been plowed the previous fall. The plats were laid out as evenly as possible in regard to physical conditions of the soil and all varieties were sown at the rate of one and one-fourth bushel per acre:

TABLE I.—Trial of Varieties of Wheat.

No. of plat.	Variety.	Source Obtained.	Days to mature.	Yield, straw per acre.	Weight, per bushel.	Yield, grain per acre, bu.
1	Red fife	Station	88	1,344	54	13.3
2	Saskatchewan	L. L. May, St. Paul	88	1,741	55	15.8
3	Bernard's hard red fife	J. J. Bernard, Pipestone	88	1,659	56	14
4	Wellman fife	Station	88	1,323	54	11.7
5	Ladoga	Station	82	1,290		2.8
6	Houston's blue stem		89	1,856	53	18.4
7	Haynes' pedigree blue stem	Haynes, Fargo, N D	89	1,653	53	16.4
Average—Fife, three plots, 1, 2, 3				1,517	54¾	14.4
Average—Blue stem, two plots, 6 and 7				1,759	53	17.4

The light yield of plot No. 4 was partly due to the fact that the seed was poor and did not germinate well and it is left out of the average at the bottom of the table. Each plat contained .476 of an acre. The result of the test of Ladoga is but another of many failures of this wheat to do as well as Red fife and Blue-stem.

OATS—VARIETIES.

During the season of 1893 seven varieties of oats were grown on rich clay soil under seemingly uniform conditions. All varieties were sown at the rate of two bushels per acre and the comparison was as good as can ordinarily be made.

TABLE II.—Oats—Variety Tests.

Plat No.	Variety.	Source Obtained.	Date Sown.	Days to Mature.	Yl'd of Straw per Acre. lbs.	W'ght Grain per Bush.	Yl'd of Grain per Acre. Bush.
1	North Star.....	L. L. May, St. Paul	May 11.	79	3,389	26.5	42.71
2	Great Northern..	Salzer, La Crosse.	May 11.	88	3,716	29	54.87
3	Lincoln	N. B. & G. Co....	May 11.	83	2,780	28.5	55.15
4	Am. White Banner	.....	May 11.	83	2,614	29.5	63.15
5	E'y White Russian	Station.....	May 11.	88	3,100	31.5	60.78
6	New York.....	.....	May 11.	79	4,489	29.5	54.50
7	Early Gothland..	L. L. May.....	May 11.	83	3,510	31.5	63.15

It will be seen by the above table that two varieties, American White Banner and Early Gothland, did a little better this year than our standard, White Russian, which is the most popular oat in Minnesota.

BARLEY—VARIETY TESTS.

Four varieties of barley were sown in the spring of 1893 on land in fairly good heart that had been spring plowed. The barley was sown at the rate of two bushels per acre.

TABLE III.—Variety Tests of Barley.

Plat No.	Variety.	Date Sown.	Days to Mature.	Yield per Acre. Straw, lbs.	Yield per Acre. Grain, Bu.
1	Black	May 19.....	68	1,507	24.16
2	Success	May 19.....	65	1,016	24.58
3	Bernard's.....	May 19.....	75	1,242	20.73
4	Highland Chief..	May 19.....	78	1,305	17.77

CORN—VARIETY TESTS, 1893.

In 1893 twenty-four varieties of corn were planted in hills three feet four inches apart each way, four kernels in a hill. The soil was a black loam, fall plowed and in fairly good heart. The yields are in case of a number of varieties most excellent. The Station now has several varieties of corn which should be propagated for general distribution. We have been making a success of corn crops for a number of years on the University Farm. The effort has been to find the best class of corn for each part of the State. We are now warranted in growing for distribution, or having grown, quantities of some of the best yielding early dents for the southern half of the State, that varieties thus tested and distributed may take the place of the low-yielding "scrub" kinds now to be found in the cribs of a very large per cent. of those who grow corn. Such dent varieties as that obtained some years since from M. H. Lamb, of Waseca, No. 3 in the table, with good height of stalk, ear well up from ground, few stools, uniform, so that nearly all ears are merchantable, early, and withal, large yielders, are what we want to grow in hills for ear and stover, for silage, and to clean our lands of weeds.

TABLE IV.—Varieties of Corn.

Plat No.	Variety.	Description.	Source Obtained.	Days to mature.	Per cent. germinated.	Date ripe. Sept.	Height of stalk. ft.	Height of stalk. in.	Distance of ear from ground Inch's.	Per cent. stools.	Per cent. m'rk't-able corn.	Stover per acre. lbs.	Shell'd corn per acre bu.
1	North Star	Yellow Dent	DeCou & Co., St. Paul, Minn	106	.77	12	6	6	36	.05	.90	3,000	61.9
2	Dakota	" "	NorthropB.&G. Co. Minneapolis, Minn	107	.90	13	7		48		.90	3,800	57.8
3	Lamb's	" "	M. H. Lamb, Waseca, Minn	104	.90	10	6	4	33	.05	.80	3,400	67.5
4	Dakota Queen	" "	Northrop B.&G.Co, Minneapolis, Minn	105	.95	11	6	6	36	.05	.80	2,900	62.5
5	New York	" "	L. P. Smith, Trumansburg, N. Y	107	.67	13	6	4	36	.05	.80	3,800	55.
6	Queen of North	" "		106	.75	12	6	3	40	.05	.75	3,000	56.4
7	Gold Coin	" "	Clearwater, Minn	106	.91	12	5	4	24	.05	.75	3,400	55.
8	King of the Earl't	" "	L. L. May, St. Paul, Minn	108	.62	14	5	4	24	.05	.75	3,200	47.8
9	Allyn's	" "	Joshua Allyn, Hastings, Minn	106	.96	12	6		28	.05	.70	3,100	54.2
10	Earl'est Canadian	" "	Salzer, La Crosse, Wis	110	.91	16	5	8	24	.05	.85	3,900	66.9
11	Boyd's	" "		100	.91	6	5		18	.05	.70	2,900	43.6
12	Minnesota King (horse tooth)	" "	NorthropB.&G. Co.Minneapolis, Minn	105	.84	11	5	6	24	.05	.85	3,300	50.3
13	North Dakota	White Flint	Salzer, La Crosse, Wis	108	.91	14	5		18	.15	.90	5,600	59 2
14	Fosston	" "	Fosston, Minn	100	.84	6	4		9	.10	.80	1,800	79.5(?)
15	New York	" "	L. P. Smith. Trumansburg, N. Y	106	.76	12	6		20	.15	.90	4,400	58.3
16	Bull's	Yellow Flint	J. A. Bull, Edina Mills, Minn	105	.77	11	4	3	16	.20	.85	3,400	55.3
17	Mercer	" "	DeCow & Co., St. Paul, Minn	100	.71	6	5	3	15	.15	.85	2,600	42.2
18	New York	" "	L. P. Smith, Trumansburg, N. Y	106	.76	12	5		24	.20	.90	4,400	54.2
19	Longfellow	" "	Station, St. Anthony Park	110	.47	16	5	6	30	.20	.70	7,100	48.1
20	Lippet's	" "	Lippett	100	.54	6	4	4	18	.10	.80	2,600	45.
21	Minnesota Flint	" "	Twombley, Wyoming, Minn	105	.46	11	4	2	20	.15	.85	2,800	43.6
22	Squaw Corn	Mixed Flint	Salzer, La Crosse, Wis	100	.65	6	4	3	15	.10	.85	2,700	40.3
23	Bull's	White Dent	J. A. Bull Edina Mills, Minn	106	.78	12	4	9	24	.24	.90	2,900	60.3
24	Elephant Fodder		NorthropB.&G.Co. Minneapolis, Minn		.51		7	6	42		.60	5,800	50.8

WHEAT—IMPLEMENTS FOR SEEDING.

During the winter of 1892 and 1893 an extensive experiment was planned for the trial of a number of different wheat seeding machines, but owing to our inability to get the implements wanted, the experiment was confined to trials of a Hoe drill, Broadcast seeder and a machine invented by W. H. Campbell, of Putney, S. D. This latter consists of two sets of narrow-tired wheels, one set of which runs two feet ahead of and alternates with the other, the whole following a seeding box and set of cultivators, the same as is on the ordinary broadcast seeder. The wheels, following the broadcast seeder, thus serve the double purpose of firming the under soil and forming a fine "dust blanket" on the surface, taking the place of the harrow.

TABLE V.—Implements for Seeding Wheat.

Plat No.	Machine Used.	Am't Seed Per Acre.	Days to Mature.	Straw Per Acre lbs.	lbs. Grain Per lb Seed.	Yield Per Acre, bu.
1	Hoe drill.....	84 lbs.	88	1,362	9.53	13.35
2	Campbell's seeder	87 lbs.	87	1,542	10.59	15.36
3	Broadcast seeder.	92 lbs.	88	1,575	10.27	15.56

While the yield per acre, as shown above, was a little smaller with Campbell's machine than with the Broadcast seeder, the conditions favorable to the largest yield with the former machine were lacking, and I am well satisfied that the machine is of merit on dry, loose soil, where the lower part of the furrow slice needs compacting.

OATS.—IMPLEMENTS FOR SEEDING.

In conjunction with the tests of implements for seeding wheat three plats were similarly seeded with oats in the same field where varieties of oats were grown.

TABLE VI.—Implements for Seeding Oats.

No.	Machine used.	Date sown.	Amount of seed per acre.	Days to mature.	Straw per acre lb	Grain per acre. Bu.
1	Hoe Drill.....	May 11.	89 lbs.	83	3085	57.46
2	Campbell's Seeder	" 11.	102 lbs.	83	3278	61.03
3	Broadcast Seeder	" 11.	100 lbs.	83	3221	61.25

In the trial of seeding oats, as in the trial of these three implements for seeding wheat, Campbell's seeder, "The North Star Roller and Seeder" gave the same yield as did the Broadcast seeder followed twice with the harrow. The land used was compact fall plowing on which broadcasted grain could do well, and here it seems that Campbell's seeder had no especial merit. Its utility will doubtless be found where spring grain is sowed on very loose fall-plowing or on spring-plowing in dry sections of country or in dry spring seasons.

OATS—METHODS OF PREPARING LAND FOR.

An experiment to test methods of preparing land for oats and the effect of cultivation on the amount of water in the soil was undertaken on a field that had been pastured several years but had been broken up in the fall of 1891 and raised a crop of corn in 1892. The soil was a light sandy loam with a gravelly subsoil. The plats contained nearly one and one half acres each, were nearly even in general characteristics and were all sown at the rate of two bushels of oats per acre. All plats were seeded with a hoe-drill after preparing the corn ground as described in the table. In our dry climate methods of cultivation designed to conserve moisture in the furrow slice, so that plants can have food elaborated and furnished to them by this richest part of the soil where they best like to feed, are worthy of critical study. In this experiment where oats were sown on corn stubble which was simply disked; on corn stubble plowed shallow; on corn stubble plowed deep; and on corn stubble plowed deep and then rolled down solid, we had a good opportunity to study the water held in the upper and lower soil at different seasons during the growth of the crop.

TABLE XIII.—Effects of Cultivation on Soil Moisture.

Plat No.	Method of Preparation.	Pounds of Moisture in one acre of Soil and Lower Soil.										Average yield of straw per acre.	Average yield of Grain per acre.
		June 20.		June 30.		July 22.		August 5.		Average for Season.			
		Soil.	Lower Soil.	Soil.	Lower Soil.	Soil.	Lower Soil.	Soil.	Lower Soil.	Soil.	Lower Soil.	Lbs.	Bush.
1 and 5.	Disced twice; harrowed twice; drilled	51,823	114,264	46,391	97,786	31,853	80,042	24,194	79,224	38,565	92,828	1,431	37.53
2 and 6.	Plowed four inches deep; harrowed twice; drilled	58 928	127,332	49,005	106,014	35,120	78,774	34,274	79,224	44,331	97,336	1,738	38.7
3 and 7.	Plowed seven inches deep. har. twice and drilled	55,049	118,264	50,230	111,568	32,670	83,308	36,345	70,240	43,573	95,844	2,051	39.52
4.	Plowed seven inches deep; rolled till very firm; drilled; harrowed	59,214	131,006	45,901	104,218	29,403	75,142	25,319	80,042	39,959	97,602	2,920	45.25

The samples for determination of water in the soil were taken on top of a hill running at a slight angle with the plats but as they were all taken on the same line, they may be considered as fairly representative of each plat although all would have shown a large amount of moisture if taken on lower land.

The samples of top soil were taken by boring down to a depth of three inches with a common post-hole auger, after first carefully removing all stubble on the surface. The samples of lower soil were taken from these same holes by boring down six inches further, using all the soil from three to nine inches deep from which to take the samples. All samples were taken and determinations made by the Chemical Division of the Experiment Station.

An acre of soil in the table means a layer of soil three inches deep, covering the surface of one acre. An acre of lower soil means the layer of soil between three and nine inches in depth, covering an area of one acre. The determinations made August 5th were from samples taken after the grain was cut. It will be seen by table No. XIII that plats Nos. 1 and 5, corn stubble disked, contained the lowest average amount of water in both surface and lower soil and gave the smallest yield of grain and straw. Plats Nos. 1 and 5 contained the least moisture in the early part of the season when plant growth was starting, but contained as much water in the lower soil at the end of the season as plats 2 and 6, plowed shallow; more than 3 and 7, plowed deep; and nearly as much as plat No. 4, plowed deep and rolled hard. At the time of seeding the already dry surface soil of the disked plats, 1 and 5, was thoroughly stirred up and dried out to a depth of three inches by the frequent discing and did not contain the necessary amount of moisture to germinate the seed placed in this loose dust blanket and to start a full growth of grain. On account of the lighter crop growing on these disked plots there was apparently not so much water pumped up from the lower soil by the plants during the latter part of the season as in the rest of the field. This allowed the accumulation of as much water in this lower soil as in the lower soil of the other while the surface soil remained

driest through the entire season, probably because of the thorough loosening in the preparation. The corn-stubble land by deeper plowing produced more grain and straw than that plowed shallow or that simply disked.

In plats 2 and 6, plowed shallow, and in 3 and 7, plowed deep, the seed was deposited in soil freshly turned up by the plow, and the shallow cultivation given by the harrow and drill did not seem to allow it to dry out so much as in the plats heretofore mentioned. They had moisture enough left to start a fair growth, though not so large as in plat No. 4, which was rolled down hard after deep plowing. Nor did they require so much water to support their less growth of grain as did the heavier yielding plat No. 4, thus leaving more moisture in the entire soil at the end of the season.

In plat No. 4, which gave the largest yield of grain and straw, the moisture was more nearly all retained by the process of rolling, and then harrowing lightly to form a "dust blanket". The water thus conserved started a strong growth of grain, which later in the season required a much larger amount of water than the lighter growth on the other plats, and brought the average amount of water down practically to that of the rest of the field.

The lessons to be drawn from this experiment, so far as a single trial can be relied upon, are that the more compact we make our seed bed and lower part of the furrow slice, and the more perfect the shallow "dust blanket," the better we can save what moisture is in the soil and apply it to the use of the growing crop at the time of germination and stooling when it needs most water. By the time the grain has gotten past the germinating and stooling period the capillary action which was interrupted by the plow has practically resumed operation and is ready to supply moisture from below. While a shallow "dust blanket" is evidently a benefit to dry soils, it can readily be seen that a "blanket" three inches deep in which to deposit seed may be a detriment.

POTATOES—METHOD OF PLANTING.

Potatoes planted so as to test several methods were planted in clover sod broken the fall previous. The rows were forty inches apart and seed pieces cut to one or two eyes were planted, as shown in tables XVI and XVII. The results illustrate the generally accepted fact that in our climate, subject to drouth, potatoes should not be planted shallow. The potatoes planted shallow not only yielded less but they were not of such good quality, having more branches or "fingers and toes." The potatoes planted deeper were comparatively free from these wart like growths, which sometimes are produced by the tubers taking on a second growth when a period of drouth is succeeded by a period when the soil is again moist.

TABLE XIV.—Methods of Planting Potatoes.

Plat No.	METHOD OF PLANTING.	Amount seed per acre. Bushels.	Days to mature.	Bushels per acre not salable.	Bushels per acre salable.	Bushels harvest'd, per bushel planted.	Total yield per acre. Bushels.
1...	Land plowed five inches deep, harrowed, marked three inches deep, hills thirty-two inches apart in the row, two seed pieces in each hill covered three inches deep with hoe	8.9	122	35.8	120.7	17.6	156.5
2...	Furrows drawn six inches deep, potatoes planted in furrows, one seed piece every fifteen inches. Furrow turned back to cover seed	11.4	122	17.2	190.3	18.2	207.5
3...	Potatoes dropped in every third furrow as the piece was plowed. Furrows six inches deep, one seed piece every fifteen inches	10.1	122	20.	180.	19.8	200

TABLE XV.—Potatoes; Depth of Planting.

Plot No.	DEPTH PLANTED.	Amount of seed per acre.	Bu. per acre not saleable.	Bu. saleable per acre.	Bu. harvested, per bushels planted.	Total bushels per acre.
1	Plowed under two inches deep and harrowed as the potatoes came up.	9.8	28.9	184.5	21.7	213.1
2	Plowed under four inches deep and harrowed as the potatoes came up.	8.9	22.	171.1	22	196.1
3	Plowed under six inches deep and harrowed as the potatoes came up.	7.7	32.9	179.7	27.6	212.6
4	Plowed under eight inches deep and harrowed as the potatoes came up.	9.3	29.4	162.3	20.6	191.7
5	Dropped in furrows eight inches deep and covered lightly, leaving soil to pull down as potatoes came up.	10.1	20.8	175.4	19.4	196.2
6	Plowed under eight inches deep and harrowed as the potatoes came up.	9.2	15.4	188.6	22.2	204.
7	Dropped in furrows eight inches deep, covered one inch deep with straw and furrow turned harrowed as the potatoes came up.	8.6	12.1	142.5	18.	154.6

OATS.

STUDY OF PER CENT. OF GERMINATION AND STOOLING OF OATS AT DIFFERENT DEPTHS OF PLANTING.

TABLE VII.—Germination of Oats at Different Depths.

Hill No.	Depth sown.	Date sown.	Per cent Seeds grown	No. of heads on plat when matured.
1	¼ inch	May 6	86	111
2	½ inch	May 6	81	127
3	¾ inch	May 6	90	103
4	1 inch	May 6	85	119
5	1¼ inches	May 6	76	112
6	1½ inches	May 6	79	113
7	1¾ inches	May 6	82	112
8	2 inches	May 6	59	125
9	2¼ inches	May 6	60	102
10	2½ inches	May 6	72	...
11	2¾ inches	May 6	60	...
12	3 inches	May 6	30	17

One hundred kernels were planted in each hill of one square foot.

The oats were able to come up nearly equally well at all depths from 1¼ inch to 1¾ inches deep, and the production of strong culms was quite as good with the deeper of these plantings. Oats planted 1½ to 2 inches deep germinated well.

BARLEY.

STUDY OF PER CENT. OF GERMINATION AND STOOLING OF BARLEY PLANTED AT DIFFERENT DEPTHS.

As in the case of oats, each hill was one foot square and was planted in depths running from ¼ to 3 inches. One hundred kernels were planted in each hill.

TABLE VIII.—Germination of Barley at Different Depths.

Hill No.	Depth sown.	Date sown.	Seeds germinated.	Heads on plot when matured
1	¼ inch	May 19	79	112
2	½ inch	May 19	92	117
3	¾ inch	May 19	84	105
4	1 inch	May 19	79	104
5	1¼ inch	May 19	63	79
6	1½ inch	May 19	62	57
7	1¾ inch	May 19	27	23
8	2 inches	May 19	33	44
9	2¼ inches	May 19	28	30
10	2½ inches	May 19	30	14
11	2¾ inches	May 19	12	0
12	3 inches	May 19	19	1

The barley planted only one inch and less in depth germinated better and produced more culms than that planted deeper.

OATS.

YIELD OF OATS SOWN AT DIFFERENT DEPTHS.

This experiment was to ascertain the yield per acre of oats sown at different depths. The plats were one rod square and the oats were sown by hand in drills six inches apart, varying in depths from one-half to three inches. Two bushels of seed per acre were used.

TABLE IX.—Oats Sown at Different Depths.

Plot No.	Depth sown.	Date Sown.	Days to mature.	Yield of straw per acre, lbs.	Yield of grain per acre, bu.
1	½ inch	May 16	76	3,200	26
2	1 inch	May 17	75	3,296	27
3	1½ inches	May 17	75	3,424	28
4	2 inches	May 17	75	3,424	28
5	2½ inches	May 17	77	3,120	32 5
6	3 inches	May 17	77	3,248	32

This date of seeding was medium as to earliness in the progress of the season. The oats sown two and one-half and three inches deep yielded the most grain and that seeded one-half and one inch yielded least, while that one and one half and two inches deep produced the most straw.

BARLEY.

YIELD WHEN SOWN AT DIFFERENT DEPTHS.

TABLE X.—Yield of Barley at Different Depths.

Plot No.	Depth sown.	Date sown.	Days to mature.	Yield of straw per acre, lbs.	Yield of grain per acre, bu.
1	½ inch	May 18	68	2,720	20.7
2	1 inch	May 18	68	2,880	26.7
3	1½ inches	May 18	68	2,918	28.
4	2 inches	May 18	68	2,848	26.
5	2½ inches	May 18	69	2,800	24.
6	3 inches	May 18	69	2,784	22.6

From the above table it will be seen that barley did best when planted one to two inches deep.

OATS—HEAVY VS. LIGHT FOR SEED.

The practice of many of the farmers of Minnesota in using their light grain for seed led to a comparison of heavy and light oats for seed. To obtain the heavy seed, oats of good weight were run through the fanning mill using all the wind possible to blow out the light oats and chaff. For light seed the oats thus blown out were recleaned using only enough wind to blow out the chaff and very lightest kernels.

TABLE XI.—Heavy vs. Light Oats for Seed.

Plot No.	Seed used.	Rate per acre.	Weight of seed per measured bushel.	Pounds seed on plot.	Kernels per bush. of 32 pounds.	Kernels on plot.	Yield of straw per acre, lbs.	Yield of grain per acre. Bushels.
1	Heavy	2 bush.	37 lbs.	31	567,296	549,568	3,389	64.09
2	Light	2 bush.	21 lbs.	14	911,872	398,944	2,492	54.59

This experiment does not show as radical a difference in the product of light and heavy seed as is usual, though the heavier seed produced 9½ bushels more of oats than the light seed. When the season and soil furnish poor seeds of good parentage, with the best of conditions, the young plants are enabled very soon to get nourishment from the soil in ample quantities and do not need a large supply stored up in the seeds for their use. But heavy seed will pay as a rule, and pay well.

OATS—EARLY VS. LATE SEEDING.

To determine the relative value of early and late seeding of oats, three plats of equal size were laid out in the same field with the experiment on "Methods of Preparing Lands for Oats." Three plots of oats were sown at intervals of about ten days, at the rate of about two bushels per acre.

TABLE XII.—Early vs. Late Seeding of Oats.

Plot No.	Date sown.	Days to mature.	Yield of straw per acre. pounds.	Yield of grain per acre. Bushels.
1	April 18	99	1,926	47.59
2	April 29	88	1,486	37.61
3	May 11	83	1,199	25.37

On the night of April 18th six inches of snow fell and remained until April 28. This retarded the germination of the grain sown on the 18th and partially accounts for the greater length of time taken to mature, while the amount of moisture stored up at that time doubtless had some influence in the increased yield.

This experiment suggests that in our extensive system of farming a great loss is sustained annually by leaving the seeding of oats until all other grain is seeded. It has been our experience that the sooner most of the small grains are put in the ground after the frost is out the better.

April 26, 1894.

University of Minnesota.

Agricultural Experiment Station.

BULLETIN No. 32.

HORTICULTURAL DIVISION.

December, 1893.

Late Blight and Rot of the Potato—Potato Scab—Cross Fertilization of Grapes—Conservation of Moisture in the Soil—Fruits: Notes on Varieties.

☞The Bulletins of this Station are mailed free to all residents of the State who make application for them.

ST. ANTHONY PARK, RAMSEY COUNTY
MINNESOTA.

Minneapolis:
Harrison & Smith, Printers.

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LATE BLIGHT AND ROT OF THE POTATO.

SAMUEL B. GREEN.

In this State we are as yet comparatively free from serious loss from late blight and rot of potato, yet in the older sections of the State, considerable loss annually occurs to the potato crop from one or both of these troubles, and in occasional years very serious damage results from them. It is undoubtedly true that the loss from this cause is very generally underestimated or not considered at all. It is the object of this article to discuss this subject briefly and to give the best known methods of combating the disease.

Late blight of the potato (*Phyopthora infestans*) and potato rot are the result of the development in the leaves or tubers of a fungus plant or mildew which by its growth robs the plant on which it grows, and prevents the natural use of the food formed in the plant, and even going so far as to break down the tissues in which it grows causing their premature decay and death. It has been known for fifty years. It attacks medium or late potatoes and seldom if ever injures early potatoes. It generally makes its appearance in July or August causing the leaves to die before the potatoes are more than one-half or two-thirds grown. It is most prevalent during moist warm weather when the fungus may often be seen as a delicate frost like mildew on the stems or leaves of the potato vines. In seasons favorable to it the tops of the entire field may be killed in a very few days from the time the disease is first noticed. In seasons not very favorable to it the tops may die prematurely but so gradually as to be mistaken for the natural maturing of the plant. I think it most often acts in the latter way in this State. From the tops the spores may pass to the tubers where they cause them to rot. This disease may be lessened by the use of Bordeaux Mixture to

which reference will be made further on. Figure 1 shows the way in which the disease often commences. It frequent-

Fig. 1. Late blight of potatoes in the early stages. *Phytophthora infestans.*

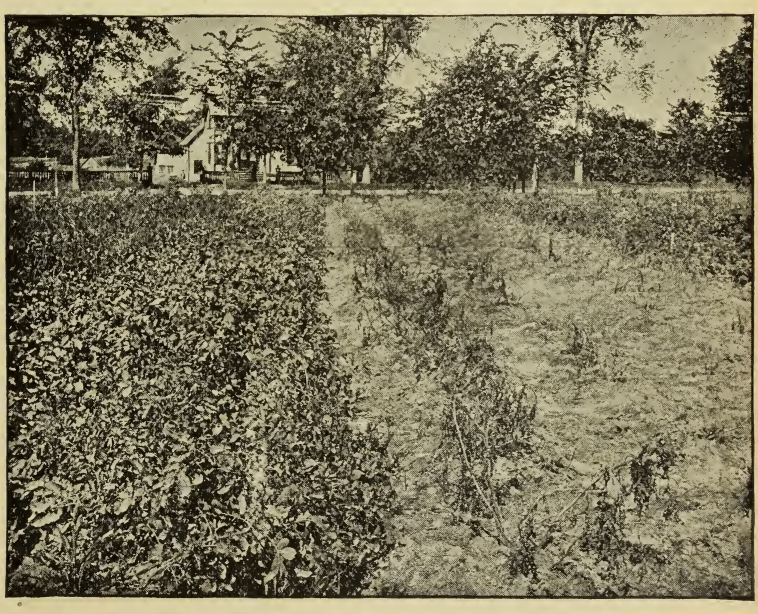
ly starts at some spot on the leaf which has been injured and from there spreads in every direction. This will many times be noticed around holes made by beetles.

EXPERIMENTS.

This subject has attracted much attention from experimenters in the older states, where the use of Bordeaux Mixture, as a preventative, has been so successful that it is becoming very generally adopted by the most progressive planters. The results are not always uniform, as there are

occasional years when the disease does not seem to be very destructive, but the increased assurance of a crop warrants its use in those sections.

At the Vermont Experiment Station, in 1893, the crop of potatoes was increased from a total of 169 bushels of White Star potatoes, where the tops were not sprayed, to a total of 400 bushels, where the tops were sprayed. This seems to many almost incredible, but when it is understood that the tops of one plat were completely dried up when the sprayed plats were fresh and green, some idea may be had of the way the treatment works. It certainly is an extraordinary increase, even for this treatment. This condition is nicely illustrated in Figure 2, which has been kindly loaned us by that Station.



Sprayed with Bordeaux Mixture. Not sprayed.

Fig. 2. View of sprayed and untreated plats of potatoes.

The Rhode Island Experiment Station increased the potato crop there, in 1890, 48 per cent. by spraying the foliage. Several other experiment stations have received very satisfactory results.

Two experiments in this line have been carried on at this Station, and they have shown a considerable increase in the crop as the result of the application of Bordeaux Mixture. In 1888, parallel rows of potatoes, each 100 feet long, were treated with Bordeax mixture, and a yield of 186 pounds per row was noted. The untreated rows yielded 143 pounds, showing an increase of 45 pounds per 100 feet. This is equal to 104 bushels per acre, or an increase of about 30 per cent. as the result of the treatment. In this case the tops of the treated row was stronger and more vigorous every way, and they remained fresh and green for two weeks after the tops of the other varieties were dead.

In the summer of 1893, on the farm of Mr. Herman Schmeltz, which adjoins the University Farm, four rows in a piece of Late Burbank potatoes, growing on very even land, were treated with Bordeaux Mixture. Shortly after the first application the tops of the treated rows were easily distinguished from those of the rest of the field by their fresher, dark green color. This difference continued to be a very prominent distinguishing mark until the tops were cut by frost. However, the tops of the whole patch continued to grow until frozen, and there was, apparently, little or no blight present, yet at the harvest the four treated rows yielded 10½ bushels of merchantable potatoes, and the untreated rows adjoining yielded eight bushels of merchantable potatoes. This is equivalent to a yield of 210 bushels from the treated rows and 160 bushels from the four rows not treated, which is equal to an increase of 50 bushels per acre. This increase seemed to be due to the fact that the tubers from the treated rows were of a larger size than the others. In the treated rows the potatoes were all merchantable, while in the untreated rows there was one-half bushel of small potatoes; an amount equal to ten bushels of small potatoes per acre.

This line of work has not been carried sufficiently far or exact enough in this State to warrant the statement that it will pay to use fungicides, but it is certainly evident that every potato grower, at least in the older portions of the State, should try this experiment in a small way the coming year.

BORDEAUX MIXTURE.

Bordeaux Mixture, the fungicide recommended, is made by dissolving 6 pounds sulphate of copper (blue vitrol) in 16 gallons of water in a wooden vessel. A barrel is good for this purpose. In another vessel slake 4 pounds of fresh lime in six gallons of water. When this has cooled, it is slowly poured into the sulphate of copper through a burlap cloth which will take out all the lumps of lime. The liquids are thoroughly mixed by stirring when the whole should be of a sky blue color. It should be prepared a few days before using. When used it should be diluted by adding to it about the same bulk of water. It is sometimes used at its full strength but it is more difficult to apply when so strong, is twice as expensive, and gives but little, if any, better results than when diluted as recommended. Three sprayings are generally sufficient though in wet seasons at least four should be applied, commencing when the tops are about half grown in ordinary years, and somewhat earlier if any signs of blight are noticed on the plants. Generally an application should be made about once in two weeks after the work is commenced.

EXPENSE OF THE WORK.

The amount used at each application will depend on the size of the tops. For the first about 100 gallons to the acre will be necessary and for the last two applications about 150 gallons each time making in all 400 gallons of Bordeaux Mixture. The cost of materials for the above formula will be:

6 lbs blue vitrol (sulphate copper) at 6c per lb	36c
4 lbs lime at ½c per lb	1½c
Cost of 44 gallons	37½c

From the above it would appear that the cost would not exceed one cent per gallon of the mixture but, as the blue vitrol may not always be obtainable at seven cents perhaps the cost might be a trifle more. At this price the cost of the material to spray one acre will be about $4. The labor involved will depend on the way in which the work is done, and for each application it may be considered about the same

as that necessary to apply Paris Green. When it is necessary to spray for the potato beetle, the Paris Green may be applied in the Bordeaux Mixture at the rate of one pound to 100 gallons of the mixture.

MANNER OF APPLYING BORDEAUX MIXTURE.

In a small way Bordeaux Mixture may be applied with a brush, broom or by any of the means used for applying Paris green and water but when the work is undertaken on a large scale, it should be put on with a force pump and a spray nozzle, and as the spray nozzle divides the liquid up into a very light spray the material goes much farther than if put on with a watering pot or brush broom. This can be done very cheaply and conveniently by rigging a barrel with a force pump and ten feet of hose with a spray nozzle. The barrel can be easily carried through the rows in a wagon. With such an arrangement from two to five acres may be sprayed in one day. The amount depending on the size of the tops. A spray nozzle is very important. At the Experiment Station we use one that is called a Nixon nozzle, but there are several other kinds which are just as good.

SUMMARY.

(1.) Late blight of potatoes is probably quite a serious source of loss to the farmers of the older sections of Minnesota.

(2.) Late blight of potatoes is caused by the same fungus that produces potato rot.

(3.) Late blight and rot of potatoes may be prevented by the application of Bordeaux Mixture to the tops of the potatoes after the vines are half grown.

(4.) It is well worth while for growers of potatoes to experiment in the use of Bordeaux Mixture for the prevention of blight and rot, although it is not recommended to treat the whole crop with it.

(5.) The cost of material for Bordeaux Mixture should not exceed $4 per acre and under favorable circumstances it may come much below this figure.

(6.) The increase in the crop from the treatment recommended may often be as much as fifty bushels per acre, and frequently much more. This increase will pay for the expense of the operation and as the potatoes are generally larger and smoother as the result of the treatment it is probable the work will pay well. In some seasons little or no results have come from the practice but such negative results are very exceptional.

(7.) The Paris green or London purple which is ordinarily applied for the potato beetle may be mixed into and applied with the Bordeaux Mixture with as good results as if applied alone. It is safer to use it thus mixed.

POTATO SCAB.

SAMUEL B. GREEN.

The losses from pototo scab (*Oospora scabies*) are so well known that no description nor statement of the loss it occasions is necessary. It attacks any and all varieties of potatoes. The cause of this trouble has been variously attributed to wood ashes, to insects, to stable manure, to heavy and light soil, to too much and too little water in the soil and to many other causes. It has been conclusively demonstrated that while some of these conditions may increase the amount and the rapidity of its development, yet no one of them nor any of them combined are the first causes in producing the disease. The real cause of the disease is a minute parasitic fungus plant that lives in the skin of the potato tuber. The growth of it there produces an irritation which induces the healthy cells to start an extra growth to repair the injury done by the fungus. This growth, which takes place under the diseased surface skin, pushes it up, thus rupturing the cells and forming the rough surface, which we call "scab." In the same manner, any growing, healthy plant overgrows injuries which it may receive. That this is so is well demonstrated by the following experiments made by Dr. R. Thaxter. A smooth potato was marked with material containing the pure potato-scab germs, in the form of a monogram of the letters "R. T.," with result shown in figure 3. In another experiment, the result of which is illustrated in figure 4, one

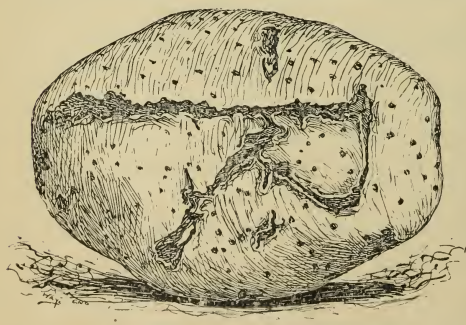


Fig. 3. Potato scab induced by inoculation in form of monogram "R. T." After Thaxter.

potato was marked with the pure scab fungus in the form of the letter "L." In the case of the small potato in figure 5, the end of it was just touched with water containing germs of the scab fungus. In each of these cases the fungus produced the roughened surface on the skin of the potato characteristic of scab, and that in a form to prove it the result of the inoculation, thus showing satisfactorily that scab is the result of the growth of germs in the skin of the potato. In this connection perhaps it should be stated that the scab fungus will grow on the surface of a potato if given warmth and moisture, whether the tuber is growing or not. In consequence of this, scabby potatoes should be dug at once when matured, since otherwise the scab will continue to grow and to cause an increase of the injury.

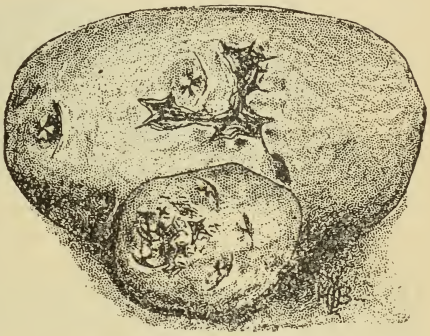


Fig. 5. Sketch of two potatoes showing the effects of artificial application of the germs of "deep scab." In the case of the large tuber the germs were taken from a culture similar to that shown in fig. 1 and applied in the form of an L. The apex of the small tuber was merely brushed with water containing germs. Natural size. After Bolley.

Another instance showing the germ character of the potato scab, and that it will live over winter in the soil and may be distributed in drainage water, came under my notice near Edina Mills, Hennepin county. A gentleman there has a piece of land on a hillside, through which is a slight depression extending down the hill. The land above his had become infected with potato scab. He broke up a piece of new land adjoining and planted it with clean seed potatoes. At harvest he found that extending down the hill in the form of the letter V, where the drainage from the land above would naturally flow, that the potatoes were scabby, while on the rest of the piece the tubers were clean and smooth. This is illustrated in figure 5, in which the part shaded with lines represents the land that produced scabby potatoes. The new land that was newly broken up is shown to the left,

and the portion of it which received the wash from the land above and was consequently infested with scab is shown by the V shaped darker part extending into the new field.

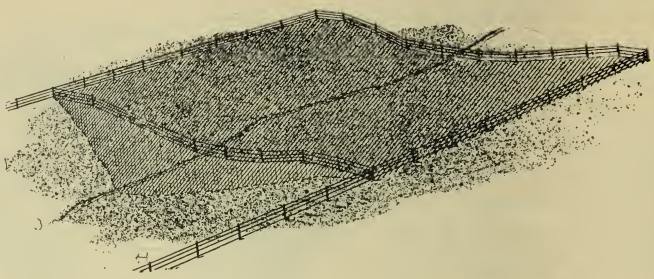


Fig. 5. Showing distribution of potato scab by drainage. The enclosure to the right and above, is land infested with potato scab. The enclosure to the left and below, the newly broken land which was planted with clean seed potatoes. The V shaped part below the fence represents the part of the new land infected with scab from the field above by drainage.

Our largest and most experienced potato growers take great pains to obtain and plant only such seed potatoes as are free from scab and not to plant on land that has produced a crop of rough potatoes. These considerations are the result of constant observations of the evil attendant on such practices.

Extensive experiments made at this Experiment Station and in many places elsewhere show plainly: (1), That scabby seed potatoes almost uniformly produce a scabby crop of tubers even if planted on new land. There are occasional exceptions to this rule but they do not occur very often. (2), That in old potato land, *i. e.*, where the scab has been harmful, the crop is almost certain to be scabby even though only perfectly healthy seed is planted.

The length of time the germs of scab will live in the soil is not known, but the experience of various growers would seem to show that they may live at least three or four years, and Prof. Bolley states it has been known to have seriously injured a crop of beets after an interval of five years from the time when a crop of scabby potatoes was harvested. In this connection it is of interest to know that

the disease called scab on beets is the same as scab on potatoes, and consequently potatoes should never follow a crop of scabby beets without an interval of at least six years, which is perhaps long enough to permit the germs to die out in the soil, but as this time may not be long enough to thoroughly cleanse the land from the germs of the scab fungus, a longer period should intervene whenever it is practicable.

IMPORTANCE OF CLEAN SEED.

The importance of having seed potatoes perfectly smooth and free from scab or from contamination by coming in contact with diseased potatoes, cannot be too firmly insisted on. It is not enough to have the seed smooth and clean, but if the clean seed potatoes have been in contact with those that are scabby, the chances are that some germs of the disease will adhere to them and be ready to grow as soon as a favorable opportunity offers. Where there is the least suspicion that clean seed potatoes are infected, or when one is using seed the history of which is not known, the chances of injury from this source will be greatly lessened, if not entirely eliminated, by thoroughly washing the tubers in running water before planting. This may be done by placing a trough where water will run through it; into this pour one layer of potatoes at a time and rub them with a broom or brush until they appear clean and bright, even in the eyes This will probably remove the germs that adhere to the skins. If such potatoes are planted on perfectly clean land, the crop from them will generally be smooth, although, even if grown from such seed potatoes, some germs may remain after the cleaning process, and the little scab thus spread may gradually increase until it becomes a source of trouble, so that, even where this method is adopted, it will be found a good plan to occasionally change the land used. A better plan would be to disinfect with corrosive sublimate, as recommended for scabby seed below.

SCABBY SEED POTATOES.

Scabby seed potatoes may be safely planted, provided that they are first treated with some material that will kill the germs of the scab fungus on the skin. Many experiments

have been made in this line with various fungicides. The most uniformly successful results have come from soaking the seed potatoes before planting in a solution of mercuric chloride. Prof. Bolley, of North Dakota, who has experimented very largely with this treatment, and been very successful in its use, recommends the following method: "Procure an ordinary barrel and fit into the base a common wooden faucet; purchase of a druggist two ounces of finely pulverized corrosive sublimate (mercuric bichloride); empty all of this into two gallons of hot water and allow it to stand over night or until apparently dissolved; place in the barrel thirteen gallons of water, then pour in the two-gallon solution; allow this solution to stand in the barrel four or five hours, during which time it is several times thoroughly agitated, to insure equality of the solution before using; select as fair seed potatoes as possible, wash off all the old dirt and immerse as many as you can or wish to treat at one time in the solution *one hour and thirty minutes;* at the end of this time turn off the solution into another vessel; the same solution may thus be used a number of times if wished. After drying, the potatoes may be cut and planted as usual. Plant upon ground that has not previously borne the disease. The potatoes may be cut before treatment if wished."

Another and perhaps more practical way is to fill a large hogshead with a solution of the strength recommended and into this dip the potatoes in coarse sacks. Allowing them to remain for one and one-half hours.

This treatment has been productive of excellent results at this experiment station.

CAUTION.

The corrosive sublimate is a strong poison and great care should be exercised in its use. The strength of the solution as here recommended is one part in one thousand; the same as that used in surgery and is not such as to work injury unless taken into the stomach. Great care should be taken in handling the pure substance, and all treated potatoes should be planted. The solution should not be placed in metallic vessels. It is a good plan to buy no more of this material than will be used at once.

Prof. W. J. Green, of the Ohio experiment station, states that potato scab at that station has been almost wholly prevented by soaking the seed before planting for one hour in Bordeaux Mixture*. There is much other evidence to show the benefits of using this fungicide for this purpose and as it is quite harmless it is well worthy of trial. At this experiment station its use has been attended with fair results, but they were not equal to those obtained where the corrosive sublimate was used.

BARNYARD MANURE THE CAUSE OF SCAB.

It has been generally observed that where stable manure is used on potato land scab is often most abundant; its presence seemed to be favorable to the development of the disease. Dr. Thaxter says that he is convinced "that the practice of feeding scabby potatoes to stock is one of the most important measures by which the disease is spread on farms." It is well known that the spores of a great number of fungus diseases pass readily through the stomach and intestines of animals without injury. It is also known that the scab fungus grows readily in manure, and it is altogether probable that these spores pass unharmed through the animals fed on scabby potatoes or scabby beets. The manure that is free from these germs will not necessarily increase the injury from scab fungus.

CONCLUSIONS.

(1). Scab of potatoes is caused by a fungus plant working in the surface of the potato. The germs of it are very abundant and live for many years in the soil and also over winter on the potatoes. If these germs are fed to stock, they undoubtedly grow in the manure and the use of such manure may often be a cause of infection. Also they may be spread in the soil by the natural drainage, and land receiving the drainage from infested fields may become infested even without ever having potatoes on them.

*The recipe for Bordeaux Mixture is given in this bulletin in the article on Late Blight of Potatoes.

(2). Scabby seed when planted on new or old potato land will generally produce a scabby crop, but the amount of the disease will generally be much more on the old than on the new land.

(3). Perfectly clean, seed planted on land which is free from the scab fungus will always and in any season produce a crop of smooth clean potatoes, no matter what the character of the land. But apparently clean seed potatoes may have the germs of the scab fungus on their surface. This is often the case where they have been sorted out from a lot that is somewhat infected with scab. In this latter case the tubers should at least be thoroughly washed in running water to remove any germs that may be present, or what is better yet be treated with corrosive sublimate (mercuric bichloride,) as recommended.

(4). Land infected by the germs of this disease will produce a more or less scabby crop, no matter how clean and smooth the seed used.

(5). Scabby potatoes should be dug as soon as mature, since the scab fungus continues to grow on the potatoes so long as they are in the ground.

(6). Scabby potatoes may safely be used for seed providing they are first treated with corrosive sublimate as recommended. The cost of this treatment is a mere trifle, not exceeding one cent a gallon for the solution used.

CROSS FERTILIZATION OF GRAPES.

SAMUEL B. GRREN.

The State Horticultural Society at its last annual meeting requested me to undertake some experiments with Moore's Early grape to determine, if possible, why it was generally such a shy bearer and especially to study its flowers and the necessity for cross-fertilizating them; it being believed by many that this variety was more fruitful when furnished with foreign pollen than when entirely dependent on its own. In working out this special line, it was decided to experiment with the cross and self-fertilization of other varieties as well as the Moore's Early. The experiments made were as follows:

On June 16, the flowers of the grapes being then not opened, six bunches each of Moore's Early, Lady, Agawam, Ives Seedling, Lindley and Brighton were covered with paper bags which were pinned carefully over the branch above the bunch. By this means the enclosed clusters were protected from pollen of other kinds which would naturally be conveyed to them by insects and perhaps by the wind. When the flowers of the different varieties had opened and the stigmas were in proper condition, three of the bags of each kind were opened and a cluster of the opened flowers of the Delaware grape inserted in them. Thus there were of each variety three bunches of flowers that were cross-fertilized and three that were self-fertilized. These were allowed to grow without being disturbed until the largest berries were about one-half inch in diameter when examination showed that Moore's Early, Ives Seedling, Lady and Agawam had set fruit perfectly whether dependent on their own pollen or cross-fertilized. Lindley and Brighton, however, while setting fruit perfectly when cross fertilized, did not produce any fruit whatever when dependent on their own pollen, but

the whole cluster withered away. This is very clearly shown in the plate herewith, in which the clusters represented in the upper row are from bags in which foreign pollen was introduced while the lower row shows the clusters from bags which had no foreign pollen.

The results show plainly that the Moore's Early produces an abundance of pollen for its own use under the conditions imposed in this experiment. An examination of its blossoms and fruit indicates that there is an abundance of pollen to fertilize the stigmas under any ordinary conditions. This is probably the case with all the varieties of grapes, in which the *Vitis labrusca* enters largely into the parentage. That this is so with the Moore's Early is shown from the perfect form of its fruit clusters in which scarcely a flower fails to produce a well developed berry.

The lack of fruit on the Moore's Early grape seems to be due (1st) to the frequent lack of developement of those prominent buds, often called fruit buds, from which the fruiting canes grow each year; (2nd) as the fruit buds are not so abundant on this variety as on some others it is the general opinion of many growers whom I have consulted and in accord with our experience at the Experiment Station, that more wood should be left on it in pruning it than on most of the kinds commonly grown. Under close pruning it is generally a light cropper while under long pruning it is quite uniformly fairly productive.

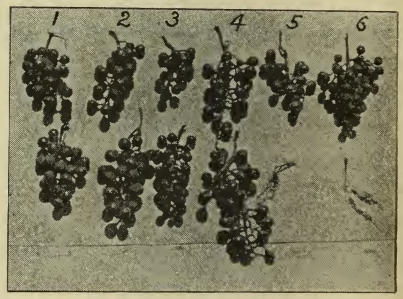


Fig. 6. Showing diffenence between cross and self fertelized grapes. Upper row cross fertellzed. Lower dependent on there own pollen. The two bunches under the different numbers are: Under 1, Moore's Early; 2, Worden; 3, Lady; 4, Agawam; 5, Lindley; 6, Brighton.

SUMMARY.

(1.) It is shown that the Moore's Early grape is not dependent on foreign pollen for fertilization.

(2.) The Lady, Agawam and Ives Seedling, are evidently independent of foreign pollen for the production of fruit, but this matter should be repeated in the case of the Agawam.

(3.) The Lindley and Brighton grape must be fertilized with foreign pollen in order to be productive, and consequently wherever planted should be near some of the strongly staminate kinds and should never be planted alone.

CONSERVATION OF MOISTURE IN THE SOIL.

SAMUEL B. GREEN.

The dry weather of the past season has brought this subject before the agriculturist as never before and all growers of crops have become impressed with its importance. The question of irrigation would be an important one for us if there was any large portion of this State that was situated so as to permit of artificial application of water. There are favored sections where artesian or other water may be used for irrigation to advantage, but generally the planter must depend on the annual rainfall. The importance then of husbanding this water is evident.

The water which reaches the soil is dissipated, (1) by running off the surface of the land into the streams; (2) by percolating through the surface soil to the underground water system; (3) by evaporating from the surface of the land. The loss of water by transpiration through the leaves of growing crops is necessary to success, over it we have no control and it is therefore not discussed here.

(1.) The loss of water from its running off into streams is quite serious on hillsides and where the land is impermeable. The methods of preventing this are numerous and must be modified according to the crops grown on the land, and its contour. Where practicable, as for instance, where the land is devoted to small fruits, surface washing may largely be controlled by covering the surface of the land with some kind of mulch which, by impeding the flow of the water allows it to soak into the ground. The necessity for this in the case of clayey hillsides is evident. There the surface of the soil when exposed becomes so hardened that the rain falling in

summer penetrates the land to so slight a depth that it is all evaporated after a very few hours of sunshine, perhaps leaving the land harder and more impermeable than before.

(2.) The loss of water by its passing through the soil to the underground water system may be considerable, but over this factor we have little control. The water holding capacity of soils varies very much and success depends largely on the proper selection of soils for different crops. This quality may often be increased by the addition of organic matter to the soil. In some parts of Europe even the prunings of grape vines and willow twigs are often used to mix with the land to increase its humus, but the plowing in of green crops and the use of stable manures are probably the most practical means for improving the water holding capacity of the soil in this section.

(3). The loss of water by evaporation from the surface of the land must be regarded the prime factor in the dissipation of the water in the soil. This may be lessened (*a*) by wind-breaks, (*b*) by mulching the surface of the soil, and (*c*) by cultivation of the surface soil. This latter method of prevention is not discussed here.

WIND-BREAKS.

It is necessary to allow a circulation of air among cultivated crops in order to prevent serious losses from fungus diseases. Where the air is very much confined and circulates but slowly, as in fields closely shut in by wind-breaks, there is liable to be serious losses from rusts, blights, mildews and the many diseases to which plants are subject, but nevertheless we can secure sufficient circulation of the atmosphere to get its beneficial action in preventing diseases and yet avoid the greatly increased rate of evaporation due to its very rapid circulation. How much the rate of evaporation is increased by exposure to the winds was clearly shown by experiments of Professor T. Russell, Jr., of the Signal Service, in 1887. The result of these experiments show that with the temperature of the air at 84° and a relative humidity of 50 per cent., evaporation with the wind blowing at five

miles an hour was 2.2 times greater than in the calm; at ten miles 3.8; at 15 miles 4.9; at 20 miles 5.7; at 25 miles 6.1, and at 30 miles per hour the wind would evaporate 6.3 times as much water as a calm atmosphere of the same temperature and humidity. Now if it is considered that the winds which sweep our prairies average a velocity of ten or more miles per hour, and not unfrequently thirty miles per hour, the losses which may be prevented by the judicious use of wind-breaks can to some extent be appreciated. Then, too, it is probable that the excessive dryness of some of the winds which occasionally sweep over the prairies is not considered in the above figures, nor is the loss considered which would come from excessive transpiration from the foliage due to this cause, and which is, very likely, no inconsiderable item. It will be understood from these facts that the wind is an important factor in the dissipation of the water from soil and that its injurious action may be prevented to a considerable extent by the judicious use of wind-breaks.

MULCHING.

Evaporation from the surface of the soil may be largely prevented by the use of mulch, and to some extent by the cultivation of the surface of the land. The use of a mulch is quite generally accepted as being desirable around trees, shrubs and small fruit plants, but its exact value is seldom expressed in figures. At the University Farm, the past season, the value of a mulch was clearly shown in many cases. In one case a strawberry bed, growing on open, clayey loam, which was heavily mulched with oat straw, produced a fine crop of strawberries, while strawberry beds in the immediate vicinity, not so treated, were nearly or quite a failure. In fact, this crop was generally a failure in Eastern Minnesota the past season, with rare exceptions. The success at the University Farm could not be ascribed to the use of any particular variety, since all the well-known kinds were productive. It would seem to be due partially to high cultivation, but chiefly to the use between the rows of a heavy mulch, which had become very compact from being under the snows all winter. Some

analyses made by Prof. Snyder, the Station chemist, gave the results set forth in the following table, in which the term mulched bed is used to signify the rows of the strawberries which at the time of the trial were covered with about three inches of broken compacted oat straw; cultivated soil means the land in an adjoining row which was kept stirred by a horse cultivator. Uncultivated soil refers to parts of the strawberry beds where the plants had failed, and consequently no cultivation whatever was given the land, neither was it mulched. The data under the heads of cultivated and uncultivated land was probably much influenced by the proximity of the mulched rows, which undoubtedly greatly increased the amount of water which they contained, so that the results in the table are much modified by it and do not appear as evident as they would otherwise. Great care was taken in selecting the samples to have them from soil of similar appearance, and the soil of the whole bed was very uniform:

TABLE I.—Water in Mulched, Tilled and Uncultivated Soil.

Date.		Depth of sample.	Mulched beds. Per cent water.	Cultivated soil. Per cent water.	Uncultiv'd soil. Per cent water.
June 29.....	Sub-soil	4 inches	24.30	19.2	18.01
June 29.....	Sub-soil	.....	25.93	19.93	20.01
June 30.....	Surface-soil	.....	20.63	15.48	.....
June 30.....	Sub-soil	.....	21.07	16.20	....

From this table it will be seen that the use of a mulch on the surface soil increased the amount of water it held about five per cent. as compared with soil which was cultivated. Calling the weight of a cubic foot of dry soil seventy pounds, which is approximately correct, it will be seen that the use of a mulch resulted in making each cubic foot of the surface soil retain about three and one-half pints of water more than it otherwise would. This is equivalent to increasing the amount of water in the upper one foot of surface soil of one acre by 605 barrels. Of course these figures are only approximate and there are many possible sources of error, yet it would seem that enough was shown to demonstrate that the use of a mulch might easily make the difference between success and failure in maturing a crop of this nature.

Physicists estimate that in order to be in the best condition for the roots of the cultivated plants to act, the soil should contain from one-third to one-half the weight of water it would contain if saturated. In this case it was found that soil when saturated would hold 55 per cent. of water, and as the mulched land contained about 24 per cent. it was in excellent condition for root action, even in a period of severe drouth.

USE OF MULCH ON A GRAVELLY KNOLL.

At the University Farm is a vineyard located on a very dry, gravelly knoll, The vines on this part suffered severely about five years ago from drouth. The following season, they were heavily mulched with stable litter and trash of various sorts such as is common about most farms, and it has been kept mulched since that time. This mulch had rotted a good deal and consequently added considerable organic matter to the soil. As the result of this treatment, the vines recovered and have since yielded good crops of fruit, and even in the past very dry season gave a bountiful harvest, not being seriously affected by the dry weather. On July 25th tests were made for moisture in the soil under the mulch in the dryer part of this vineyard and as a result the top soil was found to contain 18.3 per cent of moisture and the subsoil 21 per cent of moisture. There was no land close by with which to compare this but on the same date the soil in an oat field at the station, which was apparently and without doubt much better adapted to holding water than that in the vineyard, contained but 3.8 per cent of moisture, an amount so small that plants would probably be powerless to take up any water from it. This would indicate an increase of 14.5 per cent of water which is equivelent to an increase of about ten barrels in the upper foot of each square rod, or 1600 barrels per acre due to the use of mulch on the soil, and this conclusion seemed to be borne out by the appearance of the vines. It is my opinion that without the mulch the fruit would have all dropped from the vines in the vineyard. On August 4th, the top soil in the vineyard contained 16.3 per cent and the subsoil 17.5 per cent of water, thus showing that, while it

had lost some water it still contained a sufficient amount of water to enable the roots to work satisfactorily.

MULCHED BLACKBERRIES ON NORTH SLOPE.

In the following table is shown the amount of soil moisture under a heavy mulch on several dates during the most severe portions of the drouth of the past summer. The land where these observations were made is on the north slope of a hill. The east end of it is a little heavy, while the west is loose and gravelly. The land was used for growing blackberries and the mulch consisted of six inches of old hay put on in the spring.

TABLE II.—Showing Water in Soil Under a Heavy Mulch on North Slope.

July 22.	A. M.	East end	Top-soil..	24.1 per cent	.....	.....	
July 22.	A. M.	" "	Sub-soil..	23.9 "	.....	.....	
July 22.	P. M.	" "	Top-soil..	22.1 "	.....	.....	
July 22.	P. M.	" "	Sub-soil..	19.1 "	.....	.....	
July 25.	A. M.	" "	Top-soil..	23.8 "	West end	21.9 per cent	
July 25.	A. M.	" "	Sub-soil..	20.5 "	" "	23.5 "	
July 25.	P. M.	" "	Top-soil..	20.7 "	" "	15.5 "	
July 25.	P. M.	" "	Sub-soil..	20.2 "	" "	19.5 "	
Aug. 4.	A. M.	" "	Top-soil..	17.5 "	" "	16.4 "	
Aug. 4.	A. M.	" "	Sub-soil..	18.2 "	" "	17.3 "	

On July 27th the soil in the oat field where the land would compare favorably with the west end of the plat referred to in the preceding table, except in the matter of exposure, contained only 4.2 per cent. of water, an amount so small as to be unavailable to the roots of plants.

It will be noticed from the above table that in the thirteen days intervening between July 22d and Aug. 4th, there was a loss of seven per cent. of water, yet the soil still contained 17.5 per cent., an amount sufficient to enable the roots to work to advantage.

On July 22nd the soil in a plat of raspberries, which was near to and on land having about the same properties as that referred to in Table I, on which the strawberries were grown, was tested for its water content. The rows were seven feet apart and mulched to a distance of two and one-half feet on each side. The trials of water were made under the mulch, and in the strip of soil two feet wide between the mulch of adjoining rows, and where the constantly cultivated

soil would probably be much influenced by the proximity of the mulched land near it. The next table shows the result of these trials.

TABLE III.—Showing the per cent. of Water in Cultivated and Mulched Land in Adjoining Rows.

Date.		Mulched.	Cultived Soil.
July 27.....	Top soil.	17.6 per cent.	12.5 per cent.
July 27.....	Sub soil.	19.3 per cent.	14.5 per cent.

On the same day the soil in the oat field somewhat more sandy than the above contained 3 percent of moisture.

It will be seen from the table that even in the case of plats in close proximity, where they must influence one another, there is a considerable difference between cultivated and mulched land in favor of the latter. This difference would undoubtedly be much larger than is shown by the table if the plats treated had been isolated from one another.

SUMMARY.

(1). The water-holding and consequently drouth-resisting qualities of the soil are increased by the addition of organic matter to the soil.

(2). The loss of water by evaporation from the surface of the soil must be regarded as the prime factor in robbing the soil of its moisture.

(3). Anything that breaks the force of the wind may make the difference between success and failure in growing crops by lessening the evaporation.

(4). Evaporation from the soil may be largely prevented by the use of a mulch on the surface.

(5). The use of a mulch may sometimes increase the amount of water in the upper one foot of soil on one acre by 1,700 barrels, and it probably exerts as much influence on the several upper feet of soil. As the roots of corn and most other vigorous plants penetrate several feet into the soil the increase due to a covering of mulch must be considerable.

(6). Using the figures given in the preceding pages it will be found that a circular plat of land six feet in diameter that is mulched may have the water it contains increased in a period of drouth by eight gallons in the upper two feet of soil. This indicates the great value of a mulch around street trees.

(7). The use of a mulch on many garden crops will often make the difference between success and failure.

FRUITS---NOTES ON VARIETIES.

SAMUEL B. GREEN.

In the following notes on varieties of fruits grown at the University Farm only those are referred to which are of especial interest, have proved themselves of great value over a long period, have given promise of more than usual excellence or have been widely advertised.

PLUMS.

The crop of plums at the University Farm the past season was very large and beautifully developed. There was very little injury from the curculio. The trees are on a north slope in cultivated soil. The following varieties of special interest have fruited:

Cheney.—This variety fruited abundantly and is one of the hardiest, thriftiest and best plums ever grown at the University Farm. It is of very fine quality, very early and large. The tree is a fine, strong, healthy grower.

Rockford—Has done very well and I regard it as a variety of much value, especially for the home garden, where its productiveness and good quality will make it a favorite.

Among the older well tried varieties that have fruited the past season are the following:

De Soto.—This variety has again demonstrated its value, is reliable and productive. It still leads in these qualities and is the variety to plant if but one kind is to be set out. Of good quality.

Forest Garden.—Very productive. Not as early as the Cheney but follows closely after that kind. Of fair quality.

Rollingstone.—This variety increases in favor. Fruit of large size and excellent quality. Tree, healthy and productive. Quite distinct in habit. Growth, short and crooked.

Wolf.--This variety should be better known. Fruit large and of best quality, and a free-stone. The pit is very small. Tree thrifty and productive. One of the best kinds.

Weaver.—This variety has not fruited as heavily as usual, owing probably to its having been severely pruned back last year. I regard it as destined to be one ot the most popular kinds for marketing on account of its large size and free stone, although it is not of high quality.

APPLES.

The apple trees at the University Farm are just commencing to bear fruit, attract much attention from visitors, and the work will undoubtedly lead to valuable results. In the Russian orchard, which name is used to designate the young orchard on the level prairie at the University Farm, are planted about 300 varieties ofRussian origin: Some of these have died of blight, others have winter killed, but many of the remainder are proving to be of wonderful hardiness and of apparent adaptability to this climate. I would especially call attention to the following kinds which have fruited here the past summer. There are other very promising kinds not mentioned which have not yet fruited.

Recumbent (Lieby.)—This is perhaps the hardiest tree that produces large apples and is very free from blight. It is much hardier than Duchess of Oldenberg, which it somewhat resembles in fruit. It should be tried on every farm in the State. Season, December. An excellent cooking apple and not to be despised for eating out of hand. Often referred to as Hibernal.

Borovinka.—This variety closely resembles the Duchess of Oldenberg in every particular. A fine productive kind. Season, August and September.

Anisim (18M)—An early winter apple of best quality. The tree has not been extensively tried, but it is apparently as hardy as the Recumbent and less liable to blight. Fruit about the size of Wine Sap, which it resembles.

Breskovka.—A late summer apple of good quality for table use or for cooking. Tree, very hardy and free from blight.

Thaler (*Charlotten Thaler*).—Tree, very hardy, very productive and free from blight. Fruit of medium size and excellent quality. Season, late summer.

Blushed Calville (22 M.)—A large apple of extra dessert and cooking qualities. Season, last of August. A good tree and free from blight.

Duchess of Oldenberg is also standing well and yielding good crops in this orchard.

JUNEBERRIES.

This fruit is proving to be well adapted for cultivation. It produces abundant crops in the garden with little care and needs no winter protection. The Osage, Alpina, Chester Center and Success are the varieties which have been fruited at the University Farm. Of these, the earliest, largest, most productive and best everyway is the Success. I believe this variety could be profitably grown for market, were some practical measure devised for keeping off the robins, who are very fond of it and are not easily kept from eating it.

GRAPES

The grape crop was a very large one and generally free from insects or diseases. The varieties of grapes whieh have produced the most good fruit at the University Farm the past season are Aminia (Rogers No. 39), Cottage, Hartford, Herbert, Worden, Concord, Agawam and Brighton. Of these I regard the Cottage and Hartford as the best grapes for general planting for home use as they are hardy, early, productive and of fairly good quality. But for marketing and for favorable locations, they are not good, as they have the fault of dropping from the bunch; nor are they of the best quality. Of the new varieties fruiting this year, I would call especial attention to the following:

Green Mountain.—Which I think is destined to be popular as a very early sweet grape for home use. The vine is vigorous, very productive and the bunches of fair size, but the berries are rather small.

Colerain.—Vine vigorous and healthy. Berry large, white and of good quality. Season with Worden.

Mills.—Vine very vigorous and healthy. A late variety of a peculiar dark, purplish color. Berry of medium size and adheres well to the stem. Flesh firm and meaty with a

rich, sprightly flavor. Ripens a little later than Concord or about with the later bunches of the latter.

Rommel.—Vine very strong and vigorous. Two seasons planted, bore several bunches of fruit. Judging from these I cannot recommend it for planting. The fruit was of inferior quality and little better than Elvira. Bunches compact, of medium size and handsome; berry of medium to large size; skin thin, tough; pulp melting. Seems to be prolific. Not sufficiently tried to determine its true value.

Early Ohio.—The earliest purple grape I have ever seen. Fruited with us for the first time the past season. Berry and bunch of medium size. Berry purple, sweet and of very good quality; well colored and quite palatable on August 16th. Seems to be prolific. Vine healthy and vigorous.

Ebony.—This variety fruited with us for the first time. Of inferior quality for table use, but evidently valuable for wine. Vine vigorous and healthy.

Woodruff Red is productive and evidently hardy enough for our conditions, but the fruit is very pulpy and of poor quality.

Moor's Early.—A large, handsome, white grape of good quality. Apparently only moderately productive. Vine, vigorous and hardy. Clusters, large and compact.

THE LEAF HOPPER.

The mulched vineyard of the University Farm yielded a very heavy crop of fruit on most varieties. The novel method of cultivation adopted in this vineyard on account of the coarse, gravelly nature of the soil, has attracted much attention. A drawback to this use of mulch was this year found in the presence of the leaf-hoppers in great abundance. These insects pass the winter in leaves and trash, and it has been mentioned that their presence is a sign of a slovenly cultivation.

The vines were very free from diseases the past season.

THE STRAWBERRY.

The strawberry crop was fully up to the average at the University Farm the past season. This was largely due to the retentive soil in which the plants grew and to the fact that they were very heavily mulched. The varieties which have been most productive or are new are reported on here:

Accomack.—Perfect. Fruit small and irregular, not productive and of only moderate growth.

Atlantic.—Fruit large, rather late, roundish or irregular and bright red. Not productive. Foliage and growth fair.

Auburn.—Pistillate. Fruit roundish, conical, calyx free. Rather soft but of excellent quality and productive. Foliage and growth fair.

Beder Wood.—Perfect. Fruit broadly conical, light red, fair quality, early. Firm enough for near market.

Beverly.—Perfect. Fruit small and inferior. Foliage healthy and growth vigorous.

Belmont.—Perfect. Fruit small and irregular, moderately productive. Foliage and growth good.

Boynton.—Pistillate. Fruit of even medium size, bright red, very firm, very productive. Foliage and growth good,

Crescent.—This variety still holds its own as the most generally productive market berry. During the past three years, the Warfield and Haverland have occasionally produced more and better fruit but this has always been entitled to a high place, and it is safe to say that there is no immediate prospect of its being entirely supplanted. There is, however, a demand for larger, better fruit than this.

Daisy.—Pistillate. Fruit of fair size, rather soft and moderately productive. Foliage and growth good.

Dayton.—Perfect. Fruit dull red, small soft and scarce Foliage and growth good.

Edgar Queen. — Pistillate. Fruit irregularly conical, bright red, fair, even size, firm and productive. Foliage and growth good. A fine berry evidently of great value.

E. P. Roe.—Perfect. Fruit very scattering. Foliage fairly healthy but growth very poor.

Eureka.—Pistillate. Fruit large, good color and quality, very productive. Plants vigorous and healthy.

Farnsworth.—Fruit, small, irregular and scarce. Foliage and growth good.

Gaudy.—Fruit large and very beautiful. Foliage and growth good. Season very late and it is valued chiefly on this account. Not very productive.

Gem.—Pistillate. Fruit of medium size, bright red and firm. Foliage and growth good.

Gillespie.—Perfect. Fruit small in size and quantity and irregular. Growth poor.

Gov. Hoard.—Perfect. Fruit small and irregular. Foliage and growth good.

Great American.—Pistillate. Fruit of medium size, rather irregular, late. Foliage and growth good.

Great Pacific.—Pistillate. Fruit of fair size but irregular. It sets a large amount of fruit but fails to mature it except under very favorable circumstances. Foliage fair, growth good.

Greenville.—Pistillate. Fruit large, firm and of good color. Foliage and growth vigorous. Productive. A valuable variety.

Haverland.—Pistillate. Not so productive as Warfield but of larger size and much better quality and well worthy of being ranked among the most desirable kinds. Fruit stems short and unless heavily mulched much of the fruit will be worthless.

Leader.—Perfect. Fruit dark red, rather irregular in form; large. Not sufficiently productive for the market. Foliage and growth fair.

Lovett's Early.—Perfect. Fruit of good size and form, bright red in color, firm and very productive. Foliage and growth good.

Michel's Early.—Perfect. This variety is not sufficiently productive to warrant holding it since the introduction of the Beder Wood, which is nearly or quite as good a pollenizer and far more productive.

Middlefield.—Pistillate. Fruit of good size, bright red, conical, firm, moderately productive. Foliage and growth fair.

Mark.—Foliage and growth fair, the fruit mere worthless nubbins.

Muskingum.—Perfect. Fruit flat, with a hard bunch at the end where it was not filled out. Not productive. Foliage and growth fair.

Oliver.—Perfect. This variety is mentioned because it illustrates a fickleness in fruit production that is quite remarkable. We have grown this variety three years and have scarce got a berry from it, although there has been no general failure of the strawberry crop during that time.

Parker Earle.—Perfect. Highly reported on by some growers in the state, but at the University Farm it generally sets more fruit than it can mature well. Very productive where it ripens its fruit.

Putnam.—Pistillate. Fruit of good size, light red in color, conical. Foliage and growth good. Moderately productive.

Saunders.—Perfect. Fruit medium in size, bright red. Foliage somewhat diseased.

Southard.—Pistillate. Fruit, bright red, conical, of good size and color. Not sufficiently productive to be profitable.

Standard.—Pistillate. Fruit small and poor. Growth weak.

Stevens.—Perfect. Fruit small and sparingly produced. Growth weak.

Seedling No. 7.—Perfect. (From John Little, Granton, Ont). Fruit, very large, dark red, productive. Foliage and growth good. Very conspicuous on account of its very dark green foliage and long leaf stalks.

Seedling No. 9.—Pistillate. (From John Little, Granton, Ont). Fruit, bright red, medium size, roundish conical. Foliage and growth good. Productive. This seems to be a very valuable variety.

Seedling No. 37.—Pistillate. (From John Little, Granton, Ont). Fruit closely resembles the Warfield. Foliage and growth good. Very productive.

Swindle.—Pistillate. Sets more fruit than it can mature. Fruit rather irregular, of fair size and good color. Moderately productive. Growth and foliage good.

Tippecanoe.—Perfect. Fruit small and irregular, poor Foliage and growth fairly vigorous and healthy.

Waldron.—Perfect. Fruit very imperfect, not productive enough. Foliage and growth good.

Warfield.—Pistillate. With us, this still ranks among the few most productive kinds. But in some other sections of the state, it is not so highly considered. It is a good shipping kind and is popular for marketing. Fruit only medium in size.

West Lawn.—Pistillate. Fruit bright red, medium size, roundish, soft. Foliage and growth good. Not productive.

Waupon.—Perfect. Fruit medium size, bright red, conical. Growth moderate. Foliage good. The first picking was large and nice. After the first picking the berries were very small. Moderately productive.

Williams.—Perfect. Fruit conical, medium size. Growth and foliage good. Fairly productive.

Wilson.—Perfect. Fruit well known. Foliage and growth good. Very productive. Has done better the past season than for several years.

Wolverton.—Perfect. Fruit irregularly conical, firm and bright red. Moderately productive.

In addition to the varieties mentioned, there have been grown and fruited at the Station about four hundred seedlings from Haverland and Warfield crossed with Michel's Early. Sixty of these have been deemed worthy of further trial and some of them are very promising. All the varieties reported on were fruited in young beds. Most of the varieties also fruited on beds that were producing their second crop. In fact, the best berries came from the old beds, i. e., those that were producing their second and third crops.

The varieties that have done best with us are arranged in order as to their value as follows:

PISTILLATE KINDS.	PERFECT-FLOWERING KINDS.
Crescent,	**Beder Wood,**
Warfield,	**Michael's Early,**
Haverland,	**Wilson,**
Edgar Queen.	

LEAF ROLLER.

Our strawberry plants have been somewhat injured the past season by the leaf roller, which was quite destructive about the time the crop was nearly harvested, but by mowing and burning the tops of the plants and syringing the new foliage with Paris Green and Bordeaux Mixture the old beds were renewed and were in excellent condition on the approach of winter.

This insect in its mature state is a small moth. For the first brood the female lays her eggs on the leaves early in the summer. These soon hatch into whitish worms which roll up the leaves and eat out the green tissue, leaving it brown and dead. They go through their changes on the leaves and the females emerge during July. The worms from the second lot of eggs, which hatch in July and August, pass through the winter in the ground. Besides the remedies recommended, hand picking, or rather crushing, may be resorted to when the worms are not too abundant. They are very active and often drop quickly to the ground if disturbed, but one soon comes to understand how best to press the leaf so as to be sure and kill the worm inside.

UNIVERSITY OF MINNESOTA.

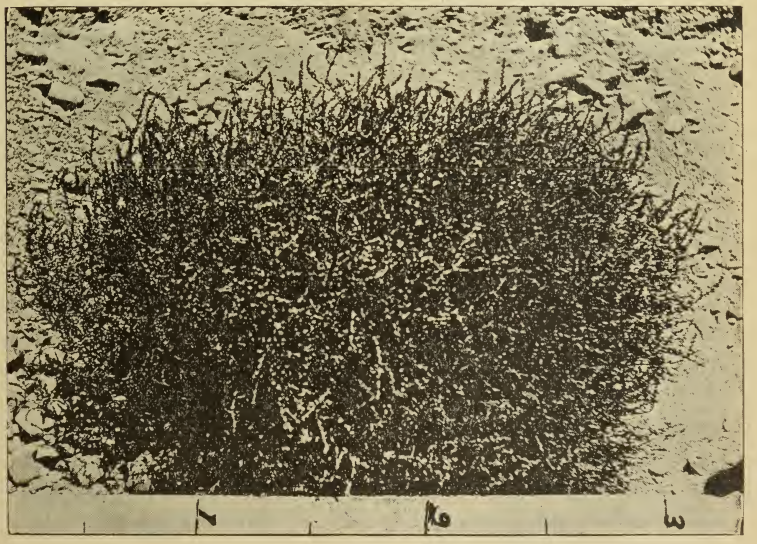
Agricultural Experiment Station.

BULLETIN No. 33.

AGRICULTURAL DIVISION.

JULY, 1894.

THE RUSSIAN THISTLE OR RUSSIAN TUMBLE WEED.



Mature Plant Photographed at St. Paul.

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.

EAGLE JOB PRINT, DELANO, MINN.

University of Minnesota.

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☞ The Bulletins of this Station are mailed free to all residents of the State who make application for them.

The Russian Thistle, or Russian Tumble Weed.

WILLET M. HAYS.

The Russian Thistle or Russian Tumble Weed (*Salsoli kali, var. tragus*) was brought from Russia, probably with flax seed, where it is said to be a most serious pest. From a very small start, in ten or more years it had gotten a very strong hold in one or two counties in South Dakota; and in six years more it has rapidly spread by the aid of the wind so as to thoroughly infest and cover numerous South Dakota and several North Dakota counties and the great body of the advance is nearly to the western border of our own state. By the aid of the railroads coming eastward this pest has much more rapidly advanced upon us than its natural mode of traveling before the wind would enable it to do. It infests our state at various points and has even passed through our own state and is causing alarm by appearing at Madison, Wis., and at other points. It has shown its ability to travel, and to thrive in a variety of conditions by migrating southward through Iowa, Nebraska, and even into more remote states. In Nebraska it has been found in nearly thirty counties. Our railroad lines are dotted or fringed with the weed at many points, and around our stockyards and many of our large terminal elevator centers it has gotten a firm and dangerous hold. It is now so situated that it can very rapidly distribute from these many centers and from the many others sure to become infested by the further importation into our state, and if left uncontrolled it will soon become a common and pernicious weed. The great body of this weed invasion will come up-

on us through our western border before the winds which drive unhindered across our nearly treeless and fenceless western prairies. Likewise from the centers infested within the state will the winds roll these weeds into our fields, scatter seeds along our wagon roads and into every nook where a weed can thrive, will this pest find a place to center as a nuisance.

When young this tumble weed is an innocent appearing plant and will not compete strongly with grass and other plants for a place. In the early stage of its growth it is a soft, succulent kind of herbage not ungrateful to stock. But if given a roomy nook, as on a freshly made gopher mound, ample room in a field of breaking, or plenty of air and sun

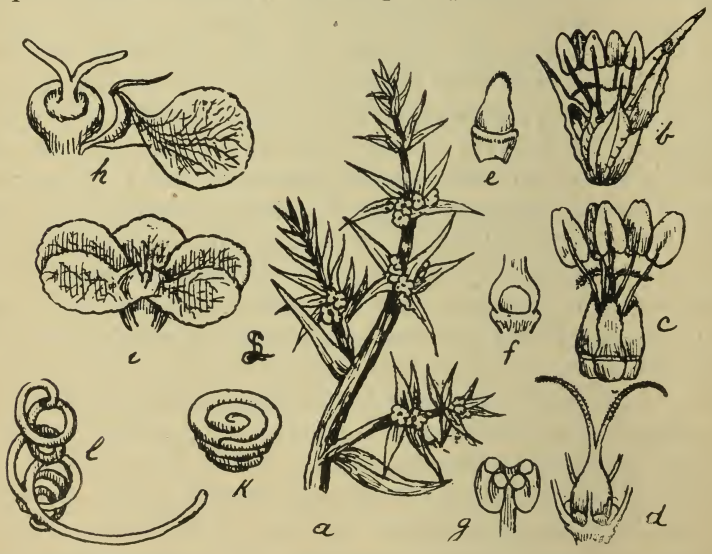

Fig. 1—a, flowering branch; b, flower, enlarged; c, flower, outer parts removed, showing male and female parts; d, female part alone; e, leaf protecting ovum; f, ovum; g, cross section of male part; h, enclosed seed; i, enclosed seed; k, seed; l, embryo with roots.—Lugger.

room along the wheel tracks in the highway, it grows as few other weeds ever grow.

It thrives in our richest soils and does nearly as well when drouth and hot winds choke most other weeds into very modest achievements. This tumble weed is like our common prairie tumble weed (Amarantus alba) in some of its characters, looks like it in fact from a distance when ma-

ture, grows in newly broken land or along roadways and is like it in its manner of tumbling before the wind. On closer examination the plant is found to be very different from the common tumble weed. When ripe its stems are much tougher and stiffer, enabling it to ride longer in the wind before being torn to pieces. At this stage of growth the slender, soft leaves born during its early stages have partly fallen off and at each joint on the stems are several leaflike spines, both strong and sharp. These are so rigid that horses legs are much injured by forcing them to pass through a growth of the nearly mature weeds. In the illustration herewith, made by Dr. Otto Lugger, drawings of parts of a stem, of flowers, etc., show the botanical features of the weed. The flower is in the axils of the leaf-like spines. The flower parts do not all fall off, but within them is developed the strange seed. This is simply a small, long-cylindrical-shaped seed or germ nearly the size of the shaft of a pin, forked at the lower or root end, and the whole coiled up into the form of a rather flat snail shell. Around this is a thin shell or covering, but no "meat" is laid up outside or around the germ as is the case in most seeds. The seed is greenish until quite ripe when it turns a dark brownish color and changes to a fairly hard seed. But the important fact is that the seed belongs to that class which is easily penetrated by water, will germinate readily and is not liable to live long in the soil, even if buried at some depth, as would such hard, oily seeds as mustard and clover.

Weeds large enough for good "tumblers" before the wind rarely grow among crops of small grain. They come from breaking, fallow ground, roadsides, freshly made mounds and like places where the native sod is temporarily destroyed and no strongly competing plants have as yet secured control. In fields of wheat, the plants are crowded out of their natural ovoid or spreading form of growth and grow more or less erect among the grain. They rarely grow tall, but if the grain has only a poor chance to thicken its clums by "stooling," as was the case in the Dakotas during the dry June of last year, the weed grows in large numbers among the wheat, and in thin spots in the grain, produces some

large plants. In seasons where the moisture enables the wheat to grow vigorously during the early part of the season, most of the Russian Tumble Weeds grow only very small or are crowded to death. Where they grow one to two feet high and rather thick among the wheat it is difficult to drive teams through them, the spines causing great pain to the horses' legs; and the harvester oft-times can not cut through the hard weeds but must give way to the header which is run above the thistles taking only the heads of the grain. In rare cases the weeds grow as high as the wheat and even the header will not work. In cultivated crops, as potatoes and corn, the occasional weed left by the careless farmer is liable to develop into the most robust tumble weed two to five feet in diameter, and in a crop of thin wheat the masses of the thistle grow large and thick enough so as to be massed together by the wind into approved "tumblers" of large size.

The great fact that this weed can and does travel from one farm to another; from waste or government lands into the fields of careful husbandmen; from the corporate or public highways to adjacent or remote fields of the cleanly farmer, brings before our states and even the general government, a new condition—a sudden and imperative duty. The individual cannot deal with this foe any more than he can protect himself from yellow fever let loose in the streets. The power of the government to bring about a co-operative, enforced, systematic and comprehensive fight must be brought into use before the pest has spread from the present comparatively small infested areas to the entire country. And if the state, possibly with aid and co-operation of the general government, compels one man to prevent this weed from spreading from his lands, it assumes the responsibility of compelling every other land owner to likewise keep it in check, that he who complies with the law may accomplish his purpose and not merely spend labor and money and have the weed again come on his fields from surrounding lands. During a recent visit to the infested region in South Dakota, I found that many farmers were making heroic efforts to keep this weed out of their own lands but as the state does not

execute its law compelling others to do the same, these farmers are placed at a great disadvantage as their fields are constantly reinfested by the weeds being blown from roadways, public lands and from the fields of other farmers.

This weed is not going to ruin Minnesota if it does gain entrance to every farm. But it is a good business proposition to invest enough of energy to prevent its ever getting a stronghold in the state. Every dollar spent on complete eradication will save hundreds in loss of crops and in the everlasting warfare which must be hereafter kept up if this pest is not subdued. A sharp, decisive contest is better than a weary, long-drawn fight which we can only bequeath to the coming generation. A successful fight would be a great and needed lesson in weed eradication.

Three alternatives are offered. First: Take no advantage from our association in organized towns, counties, states and nation, but allow each farmer to fight his own battles with the weeds blowing on his lands during most months of the year from surrounding fields, roads, etc. Second: Make and execute laws preventing the ripening of all weeds which grow large enough to be blown before the wind, and to prevent their being spread by such means as railroads and grain dealers. This plan would result in the weed spreading only very slowly to sections not now infested. If the law were faithfully executed, it would result in the farmer who strongly desired to keep his land clean of the weed being able to do so. The presence in all infested regions of small plants among grain and in other places where they would not develop into large weeds would, however, be a constant menace and source of trouble and expense. The seeds are rather light and have something of a wing which will enable the wind to carry them across snow in winter. Third: Make state laws under which, with some aid from the general government, the weed might, if possible, be completely eradicated. If practicable this plan would in the end be far more economical. Killing out the last plant of so widely distributed a weed would indeed be difficult. No one has yet investigated the subject enough to be warranted in say-

ing whether or not it is practicable, or not economy, to try to eradicate this pest as was done with pleuro-pneumonia in cattle. This whole matter should be carefully considered from a purely business standpoint and a plan devised whereby the states affected and even the general government could unite in enacting laws under which all individuals, corporations, and governing powers could co-operate to handle this weed in the most business-like and practical manner. A strong commission of men should be appointed to look up all the economic, the agricultural, the business and the legal aspects of the case and report suggestions of a general plan under which the law-making bodies of states and government could intelligently act. Recent careful study of the affected territory has made me a firm believer that the necessary energy and money to control, and possibly to eradicate, this weed could be expended by the farmers, the states and the general government to the advantage of all.

HOW TO ERADICATE THE RUSSIAN TUMBLE WEED IN MINNESOTA AND PREVENT ITS GETTING ON OUR FARMS.

A year's experience will tell us how to meet the difficulties. No one has heretofore been able to fight this weed alone. *It is an annual, however,* grows from the seed each year, and *the plants are easily killed by means of the hoe, cultivator or any tool or implement which will uproot or seriously disturb them.* They are easily pulled up, and when turned under with the plow they die. The individuals are easily killed. *If all plants large enough to travel before the wind are kept from ripening, the weed will not be very hard to eradicate* on each farm.

By preventing plants from seeding for two years the pest would disappear. That might not be possible. But it looks reasonable that the plants could so nearly all be kept down for two years that occasional sources of remaining danger points could be found and looked after, and in a few years the land be freed entirely from the pest. The essential need is, not to allow any plants to mature seeds, especially

plants large enough to roll. The seeds already ripe in the land should be encouraged to germinate that they may be killed by plow, hoe, frost and other agencies. There is no easy "cure-all," no specific except eternal vigilance; brains for a plan and willing hands on the spot to do the work at the right time.

The methods enumerated below are along the line we must act—they are written before, not after, the execution of the work and apply to the section worst infested and to the scattering patches in Minnesota. They will suggest to the ingenious farmer and to the official, what he can do under his conditions.

METHODS IN CULTIVATED LANDS.

(1) *The green manure fallow*, when large fields must be dealt with, is valuable if rightly managed, to kill Russian Thistle, and other weeds as well. Two plowings are necessary. The best way is to plow shallow in May or June and sow half a bushel per acre of millet or two bushels of oats and plow under when beginning to head out. The humus gotten into the soil will amply repay the cost of the seed for the green manure, though the thistles can be as effectively treated without the crop of green manure. After the last plowing the field should be gone over, with the hoe if necessary, to destroy stray plants.

(2) *Early fall plowing* of stubble done as soon as the grain can possibly be stacked or threshed will kill most of the weeds if great care is given to thoroughness and plowing before any seeds are ripe enough to grow.

(3) *The bare fallow* in some cases is the best means to use in cultivated lands. To make it the most effective the grain shocks of the previous crop should be stacked as soon as dry, not waiting to thresh out of the shock unless it can be done at once; and the stubble immediately plowed or even disked to kill unripe weeds or to bury ripe seeds that they may surely be induced to germinate. The land in most sections should the next season be twice fallow-plowed, once in June or July, and where necessary at or after harvest. As

practiced at present where the land lies from one harvest through the entire season, with only once fallow-plowing in midsummer, the bare fallow often is productive of the largest "tumblers" and spreads the weeds.

(4) *Annual hay crops* grown instead of green manure will likewise serve a good purpose and in sections where wild hay is no longer plentiful will pay as a crop. By very early fall plowing, then plowing shallow in spring and seeding to millet, oats, oats and peas, sowed corn, or other crop for cured forage, and again fall-plowing very early, the Russian Thistle will not have a chance to seed for two years, and will be practically killed out if no seeds are allowed to blow into the field.

(5) *Cultivated crops*, early fall plowing, fallowing, among which every stray plant not killed by means of the cultivator is destroyed by the hoe, is a very effective means of killing out Russian Tumble Weed and these crops, especially corn and potatoes, can be much extended with profit on our wheat farms, but poorly tended they are a source of infection. A few plants allowed room and cultivation will develop into the largest and most dangerous Tumble Weeds. Thorough work with the cultivator supplemented by complete hoe work up to the latter part of August will surely leave no plants with age enough to mature their seeds before frost.

(6) *Mowing and burning* the stubbles and weeds as soon as the grain crop is off and before the weed seeds are ripe is a valuable means where the weeds are thick and cannot be well turned under with the plow. This plan followed by one of the methods stated above would be effective. The Russian Tumble Weed and grain stubble will not as a rule burn readily in the fall, at least not until many of the seeds have ripened, unless first mowed and dried. In some cases they may be burned after mowing without raking, which is an advantage as seeds are thus destroyed which might have escaped the mower. In other cases they must be more or less raked into piles. Plants mowed before the seeds are quite ripe will probably hold their seeds more tightly.

(7) *Mow or hoe patches in the grain* fields where a poor stand of grain has allowed them to develop into large weeds. This is necessary to avoid trouble to teams and machines at harvest time, and also to prevent the development of large "tumblers" which if allowed to ripen may be blown about scattering the seeds. Generally the scythe will do the work. The hoe or even the horse mowing machine may at times be better.

(8) *Plow under poor grain* crops for green manure if they promise to pay but little more than the cost of harvesting and threshing and are filled with a thick growth of Russian Tumble Weeds. It sometimes pays to be heroic in this. The plowing can be done early when there is little pressing work to do. The green crop of hay and weeds will make much humus or fertility in the soil and a chance for double profits on the crop the next season- Sometimes green manuring and summer fallowing are objectionable means in dry, wind-swept sections on account of resulting blowing or drifting of the fine surface soil.

HIGHWAYS, RAILWAYS, GRASS LANDS, COMMONS, GROVES.

Total eradication outside of cultivated fields is not so easily accomplished as in the lands used for grain and hoed crops.

(9) *Infested highways* which have been shaped up with the elevating grader or the reversible road machine can be easily kept clean of the weeds by one or few dressings during the summer with the reversible road machine. Plants which escape this treatment can be cut with hoe. In some cases it will pay to "break and back-set" the roadway to kill out the weeds. The farmer can use this land for crops or it can soon be seeded down to grass, timothy, Kentucky blue grass, red top and white clover being the best mixture I can recommend. Road ditches should be built of such shape or form that they are not weed strongholds. Road officers should look sharply after the weeds in all highways and see that the farmers keep them from seeding along their lands or that the roads are kept free of weeds at the expense of the township. Farmers should be encouraged to farm the land to the wheel track along infested highways.

(10) *Along rough highways* and on the railway right of way "Breaking and back-setting," possibly followed by a year of bare fallowing, then the next year seeding to grass, will sometimes be the most economical measure. Usually the hoe thoroughly applied is the best remedy. The scythe leaves low lying branches uncut to ripen seeds. Our railway right of ways as well as our highways in all sections of country should be left in such shape, when being constructed, that they can be seeded to grasses which are easily mowed or "back fired" both to lessen the number of escaping fires and to abate the weed nuisance.

(11) *Pastures and meadows* whether native or wild need attention "Breaking and back-setting," then growing crops and treating as in 1 to 8 above is safest. In grass lands left undisturbed the hoe in the hands of careful men in August is probably the best means. A foreman on horseback following and constantly inspecting the work of a gang of a dozen men could rapidly get over the prairie or tame pasture or meadow and do the work effectively, and cheaply as in a similar way we pull mustard. Prof. Bolley, of North Dakota Experiment Station, says: "A comparatively small force of workmen would suffice to destroy all weeds upon road margins and the wild lands of the worst infested townships in the state." Thus could the larger weeds which develop in gopher mounds, fire breaks and similar places on the prairies be destroyed, and the plants, kept small by the thick growth of grass, might thus be gradually eradicated.

(12) *Cities and towns in Minnesota* in which this weed has obtained a hold should, in the common interest, and in justice to the farmers who patronize them, at once take measures to prevent not only all large plants from blowing about and spreading the weed, but see that no seeds are ripened in the next years. Cities and towns are strongholds for this pest which the farmers cannot reach; and as towns are now centres from which the weed is spreading there is nothing improper in their taking the initiative. Every waste lot or block in every town or city should be broken and sowed to Kentucky blue grass and white clover. Aside from keep-

ing out this and other weed pests, such a practice would make our towns look much prettier and cleaner.

(13) *Prevention of spreading.* The greatest barrier to the spreading of the Russian Tumble Weed is the prevention of all plants growing large enough to roll before the wind. If every township can be so organized this summer as to prevent spreading by the wind, each farmer can successfully fight his own battles and all working together could in two or three years eradicate the weed. Railroads have helped to spread it. They should vigorously set about cleaning it off their right of way and out of their depot yards. Township road overseers and citizens should not hesitate to notify the railroad of the presence of the weeds on the right of way and in depot yards, and to see that the companies look after keeping their properties clean.

(14) *Fences catch the "tumblers"* and keep them out of the field. Wire fences serve a good purpose, though the weeds often pile high and blow over. Three rows of Russian Sunflower around a field inside the fence, rows three to four feet apart and seeds a foot or less apart in the row and well cultivated so as to grow tall and strong would make something of a hedge but are only temporary and not very promising. The heads make good feed for poultry and other stock while the stalks remain erect all winter. Willow hedges in double rows thirty feet apart, and cuttings a foot apart in the row make the best of hedges. A row or two of plums between the two rows of willows is suggested as an improvement. Hedges and timber belts, however, are the hardest place from which to rid out the last weed because hard to cultivate.

(15) *Ripe seeds should be burned* wherever it is possible to burn the field over or to burn piles of the weeds. Thus will it be possible to kill very many seeds in the spring or late in the fall. Wherever an opportunity offers in a strong wind in dry weather unusual efforts should be put forth to burn stubble and prairie grass. Mowing, raking, and then burning will also assist to kill many weeds. An iron drag with team hitched twelve feet away by means of a gas pipe cross-tree and chains or wires and dragged through the field of ripe

thistles, with fire burning the thistles caught in the drag as it is run along the side of the field and against the wind—is often the most practical way of burning ripe Russian Thistles.

GENERAL PRECAUTIONS.

Infested flax, millet and buckwheat seeds, or seeds of other crops harvested late in the fall after the Russian thistle has ripened, cause the spread of this weed. Farmers should carefully examine all seeds coming from a distance and discard all having seeds of this or any other noxious weed. As these seeds are rather light they can be nearly all cleaned out of most kinds of grain by using a common fanning mill with its blast and sieves properly adjusted.

Railways and Individuals handling grains, stock or other farm products from infested districts should be compelled to use care in cleaning cars at only certain places where the weeds may be destroyed and to use proper care in preventing the spread of this weed.

LAWS ARE NEEDED.

The two Dakotas have fairly good laws and Nebraska, Minnesota, Iowa and Wisconsin, and possibly other states, should each at the earliest possible opportunity enact laws making it obligatory for the proper officials of each township, city and county to see that this weed is controlled. As to whether it is practicable to entirely eradicate the Russian Thistle from the country there is a diversity of reasonable opinion. But that the state and general government owes to every farmer enough of protection that this seed may not be blown upon his fields from surrounding lands and roadways, all must admit. Whether it is wise for the government to aid the states in a trial at utter eradication is one question; the consideration of practical laws looking to preventing the ripening and blowing about of all weeds large enough to roll before the wind is another question. Any of these states refusing to do at least this much is not loyal to its own citizens nor careful of the interests of its neighbors. And the government to be loyal to one or two of its young states and their farmers may find it wise to give material support as well as its great moral support to laws looking to the eradi-

cation of this new pest. The individual farmer can fight his own battle if the state will provide so that he need not fight it over again the next year. It might be far cheaper in the end to entirely eradicate the weed than to continually fight it, as the farmer must be given a chance to keep his land clean if he is so disposed. With the weeds blowing upon his farm every year he must adapt his farming to the presence of this weed and the farmers in affected districts recognize this as a very serious pest. Real estate dealers, however, do not all recognize that this or any other disadvantage exists in their section of the country. Let the state make and execute a good law and three-fourths of our farmers, if not nearly all, would learn that total eradication on their own lands is economy. It would not be very difficult to execute a law preventing the ripening of all the large weeds. This would in the main stop the rapid spread of the weed and its entire eradication could be taken up in any section or in the entire country.

Every farmer should try to prevent the ripening of all "tumblers" on his lands and in the township and county. He should also favor and work for the making and the execution of some reasonable, comprehensive and efficient laws. Figures 2 and 3 show Russian Tumble Weed at stage when nearly ready to blossom and when all stray plants should be destroyed as recommended in sections 9 to 15.

Fig. 2—A young Russian Tumble Weed of spreading habit, over two feet across, photographed by Prof. Swem at St. Paul July 1st.

Everyone should know the Russian Thistle.

Mounted dry specimens of Russian Thistle showing it as it appears in July and August--themonths in which all plants in neglected places on roads, on breaking, in towns, etc., should be killed---will be sent free on application to all school districts, road overseers, railway section foremen and other officials responsible for killing noxious weeds.

Fig. 3—A Russian Tumble Weed of rather erect habit, 18 inches high and at age when spines are beginning to develop and the slender foliage is beginning to drop off. Photographed at St. Paul, July 1st, 1894.

University of Minnesota.

Agricultural Experiment Station.

BULLETIN No. 34.

CHEMICAL DIVISION.

SEPTEMBER, 1894.

I. The Chemical Development and Value of Red Clover.

II. The Russian Thistle. Its Food Value and Draft upon the Soil.

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.

EAGLE JOB PRINT, DELANO, MINN.

University of Minnesota.

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☞ The Bulletins of this Station are mailed free to all residents of the State who make application for them.

The Chemical Development and Value of Red Clover.

HARRY SNYDER.

Object of Bulletin.—The value of clover as a farm crop is so well known that little need be said by way of introduction as to the importance of the clover crop. Recognizing its importance, many farmers of the state have attempted to raise clover but with indifferent results; hence a complete chemical study of the clover plant was undertaken to obtain a knowledge of some of the more important facts in connection with its growth.

The Failure of Clover not Due to Deficiency of Plant Food in the Soil.—In a few cases where clover has made a poor showing, farmers have sent samples of the soil to the laboratory for chemical analysis, thinking that the cause might possibly be due to the want of some special form of plant food in the soil. The analyses, in all of these cases, have not shown the absence of any of the essential materials for crop growth. From the numerous analyses of soils, partial results of which are published in Bulletin No. 30, it is to be noted that all of the types of soil in the state are well supplied with lime, phosphates, magnesia and potash. This, coupled with the fact that clover does thrive under certain conditions and in certain seasons, indicates that the cause of the failure is due more to the want of the proper mechanical conditions of the soil, as the right time and best crop to seed it with, than to the absence of any special plant food from the soil.

These necessary conditions for clover culture can be learned only after a careful series of experiments in different parts of the state, on different types of soil and under different climatic conditions. This work has already been outlined and undertaken by Professor Hays, agriculturist of the station.

Clover Influenced by Crop with which it is Seeded.—That the yield of clover is influenced by the crop with which it is seeded is shown from the following data: Two adjoining plots of land, an eighth of an acre each, had been in corn for two years (1891-92). The plots were fall plowed and in every way had received the same treatment. In the spring of 1893, one plot was seeded with oats and clover, and the other one to wheat and clover. In the following year 1894, the yields from each of the plots were:

Clover seeded with oats—295 lbs., ⅛ acre plot at the rate of 2,360 lbs. per acre.
Clover seeded with wheat—545 lbs., ⅛ acre plot at the rate of 4,360 lbs. per acre.

A difference of a ton per acre in favor of the clover seeded with wheat.

A review of the growing conditions of the clover in these two plots shows that with the oats, the clover had the disadvantage of being compelled to compete with a more rapid growing, and an earlier maturing crop than when the clover was grown with the slower ripening wheat. The oats were harvested about two weeks earlier than the wheat. This was a period of drought. The oats being harvested left the soil and young clover exposed to the sun, while the young clover which had been sown with wheat was protected until the conditions were more favorable when the wheat was harvested.

On this point Professor Hays says that the poorer chance of the clover seeded with the oats, to get started, was also due to the fact that the oats are apt to grow very rank and dense and that the clover seeded with the oats is far more slender and weak than the plants sown with the wheat, which leaves the clover less able to stand drought and hot weather that may come later in the season, after the oats and wheat are cut.

After a careful series of experiments with raising clover in different parts of the state, many important facts in connection with its growth, will doubtless be observed.

The work recorded in this bulletin has reference mainly to the results of the chemical examinations of clover at different stages of its growth, together with the separate examination of a number of samples of clover grown in different parts of the state.

The Different Periods of Development of Clover.—Sampling.—The clover plant is considered at five different periods in its development. At each of the earlier periods three samples were taken from known areas. One sample was separated into leaves, stems, etc., and each part analyzed separately. In the second sample the entire plant above ground was taken, while with the third sample particular attention was paid to securing the roots. Working in this way the result of each period is duplicated; absolute agreement is not secured among all the duplicates because the clover plants from two different areas are not alike in all respects, yet the results taken as a whole show a satisfactory agreement for each of the periods.

In the first period, the clover was five to six inches in height, the flower head had not yet made its appearance. In the second period, twenty-four days later, the clover was in early bloom and making a very rapid growth. The clover in the third period, fourteen days later, was just a little past full bloom,—in the condition, as will be seen later, for making the best hay. At the end of flowering, and when the clover was ripe, samples were again taken.

The Rate of Formation of Food Constituents.—In order to follow, in a general way, the entire plant above ground through each of the separate periods, the analyses have been calculated to pounds of dry matter, ash, etc., for each period. The largest amount of dry matter, which is found at the flowering is taken as 100, and the largest amount of ash or mineral matter at the end of flowering as 100, and each of the largest amounts of the other compounds that are found in any of the periods as 100. The following table will show the comparative amounts that were present at each of the various periods.

CLOVER AT DIFFERENT STAGES OF GROWTH.

TABLE I—FOOD CONSTITUENTS.

	Dry Matter...	Ash	Nitrogenous Matter	Nitrogenous Matter in the form of proteids.....	Fiber .....
1. Flower Head Invisible.....	9	14	15	67	5
2. Early Bloom.....	31	46	37	70	24
3. Full Bloom	97	98	100	88	92
4. End of Flowering.....	100	100	96	85	96
5. Maturity	97	95	94	83	100

NOTE.—In the table the nitrogenous matter in the form of proteids is represented on the basis of the total nitrogenous material of that period taken as 100. It is the per cent. of total nitrogenous material of each period which is in the form of proteids, as determined by Stutzer's method.

The Earlier Stages of Plant Growth.—This table shows that the most active growing period of the clover is between early and full bloom when sixty per cent. of the dry matter is formed, fifty-eight per cent. of the mineral matter is taken from the soil, and sixty-three per cent. of the nitrogenous matter is produced. The largest yield of clover would be obtained at the end of flowering, but it would not contain as much nitrogenous matter, the important bone and muscle forming material, as when the crop was in full bloom.

Development of the Nitrogenous Compounds.—In the earlier stages of the plant growth there is not so much of the nitrogenous matter in the more valuable form of proteids as when the plant becomes more mature. At the time of full bloom the nitrogenous materials in the clover are in the most valuable food forms. From the time of early bloom until the period of full bloom, a large portion of the nitrogenous materials are assimilated and undergo the transformation from

lower (amido) compounds to the more highly organized and valuable food compounds of protein.

The Ripening Period.—The period of full bloom marks the end of the formation of nitrogenous materials. Between full bloom and the end of flowering only two and three per cent. respectively, of mineral matter and dry matter are added to the crop. The period of ripening is simply a period of re-arranging the materials that are already within the plant, and not a period of addition of any new material.

Best Time for Cutting Clover Hay.—The clover hay cut at the time of full bloom contains the largest amount of nitrogenous material in the most valuable food forms, while clover cut at the end of flowering contains the largest amount of dry matter, which is poorer in the valuable nitrogenous compounds.

The largest amount of nitrogen present in the clover plant as found by Dietrich and by Wolff, was at the time of full bloom. Dietrich's results show a decline of 10 per cent. of the nitrogen from full bloom until maturity. (Annales de la Science Agronomique, 1888.)

Assimilation of the Separate Ash Elements.—Of the separate ash elements, potash and lime appear to be assimilated a little in advance of most of the other elements. At the time of full bloom, all of the potash has been taken up by the plant, while the end of flowering marks the highest point reached by the lime and phosphates. The fourth period, end of flowering, marks a period of decline in the potash, which is even greater at the time of maturity.

Retrograde Movement of the Potash.—There is more potash in the clover plant at the time of early bloom than at maturity. This is due to the retrograde movement of the potash at the approach of maturity. The clover crop requires a larger working supply of potash than the amount that is represented in the crop at maturity. In the work of Wolff on the clover, previously referred to, there is a decline of five per cent. in the potash.

The following table gives the rate of assimilation of the principal ash elements of the clover. The highest amount reached in any of the periods is taken as 100.

CLOVER AT DIFFERENT STAGES OF GROWTH.

TABLE II—ASH ELEMENTS.

	Potash	Lime	Magnesia	Phosphates
Flower Head Invisible	15	15	8	14
Early Bloom	50	37	35	34
Fall Bloom	100	97	100	98
End of Flowering	94	100	92	100
Maturity	86	97	91	98

Compared with the growth of the wheat plant, results of which are published in Bulletin 29 of this Station, it will be observed that with the clover there is a more general relationship between the assimilation of the mineral matter and the formation of organic matter. In the first periods of the clover the mineral matter is taken up somewhat in advance of the formation of organic matter, while in the wheat the nitrogen and separate ash elements are assimilated much earlier in the development of the plant.

Mineral Food Required to Grow a Clover Crop.—Taking the entire crop of clover from the plot seeded with wheat, which gave a yield of 4,360 pounds per acre of field cured clover, the pounds of the separate ash materials removed in one acre of the crop are as follows:

Potash	66.	pounds.
Lime	76.4	"
Soda	1.	"
Magnesia	17.4	"
Iron	1.3	"
Phosphates	28.4	"
Sulphates	5.6	"
Carbonates	33.6	"
Chlorine	6.0	"
Silica	15.8	"
Total	251.5	"

Characteristics of the Ash of Clover.—The above table shows the characteristic food of the clover, and the amount of mineral matter that must be furnished by the soil for a good crop. The silica is small compared with wheat, which removes 114 pounds and more per acre. The phosphates are a little lower than the amouut found in a wheat crop. Lime and potash are the two compounds which are required in the largest amounts. The large amount of lime in the clover has caused it to be known as a lime plant.

Best Kinds of Manure for Clover.—Lime in the form of land plaster, and potash in the form of ashes are the most profitable and best materials that can be used on clover. They both have a very beneficial effect in "bringing in clover."

Composition of the Leaves and Stem.—The analyses of the separate parts of the clover plant at the different stages of their development, show that the leaves are very rich in nitrogenous material; from sixty to seventy per cent. of the entire nitrogen in the plant, excepting the roots, is present in the leaves. The first time the leaves were analyzed they contained over thirty per cent. of nitrogenous material—a very high figure and one that is not far from the amount found in the animal body. The leaves also contain a proportionally less amount of fiber. As the plant matures there is a gradual decrease in the proportional amount of nitrogenous compounds in the leaf, and a corresponding increase of fiber and other non-nitrogenous compounds. Over half of the total ash elements of the clover are found in the leaf, with a proportionally higher figure for the lime and potash.

The separate analyses of the clover leaf show its food value to such an extent as to demand that every possible effort be made, in harvesting and handling the crop, to prevent mechanical losses such as breaking the leaves.

Other minor characteristics can be observed from the tables given on the following pages.

Table III gives the composition of the dry matter, and the ash of the entire plant, excepting of the roots, at the five different periods discussed in this bulletin.

The figures under the heading of dry matter represent the

nitrogenous material, fiber, ash, etc., that are present in one hundred pounds of the dry clover. The clover hay, field-cured and ready for feeding, contains from ten to fifteen per cent. of water, and when one hundred pounds of clover is fed a correspondingly smaller amount of nitrogenous material, etc., are present than is represented in these tables. Since the amount of water that is present is subject to variations, the results are calculated on the perfectly dry material.

The term dry matter is used to indicate the perfectly dry clover. All of the water is removed by drying the substance for several hours, in a drying oven, at the temperature of boiling water. The drying oven is made of copper and has double walls. The space between the walls is filled with water which is kept boiling. When any material is dried in such an oven it will give up the water which it contains and leave the dry substance.

In order to change the results from dry substance to original substance a simple calculation will illustrate the method. In the first period, when the clover is very young a hundred pounds of it contains 86 pounds of water and 14 pounds of dry matter. The analysis of the dry matter showed 23.61 per cent. of total nitrogenous material; 14 pounds of dry matter would then contain (14 x .2361) 3.36 pounds of nitrogenous matter. The 14 pounds of dry matter is all there is in 100 pounds of the green clover. Hence, if the green clover had been used for fodder, 100 pounds would have contained 3.36 pounds of total nitrogenous material.

The figures for the ash are the amounts of the separate constituents in every hundred pounds of the ash for that period. The amount of each separate ash element in the uncut clover is calculated in the following way: In the first period there is 14 per cent. of dry matter. The analysis of the dry matter shows 10.57 per cent. of ash of which 32.75 per cent. is lime. Hence there is (14 x .1057) 1.48 per cent. of ash in the clover as it stands in the field; 32.75 per cent. of this ash is lime which is equivalent to (32.75 x .0148) .48 of lime in the uncut clover.

In order to avoid too many tables the results in the remaining tables of this Bulletin are all expressed on the dry matter and the ash constituents in per cents. of the total ash.

TABLE III.

COMPOSITION OF CLOVER, ENTIRE PLANT (EXCEPT ROOTS) AT DIFFERENT STAGES.

	I Flower Head Invisible	II Early Bloom	III Full Bloom	IV End of Flowering	V Ripe
Water	86.00	85.59	74.96	71.65	33.47
Dry Matter	14.00	14.41	25.04	28 35	66-53
COMPOSITION OF DRY MATTER.					
Ash	10.57	10.22	6.87	7.02	6.21
Ether Extract	5.35	4.70	5.73	4.26	3.92
Total Nitrogenous	23 61	17 19	14.81	14.40	14.06
Crude Fiber	13.37	20.08	24.62	25.28	26.60
COMPOSITION OF THE ASH.					
Total Insoluble (sand)	6.94	4.44	4.62	6.24	7.16
Potash	28.26	29.48	29.16	26.12	25.12
Soda	1.82	2.42	.72	.41	.60
Lime	32.75	24.32	30.64	30.22	30.66
Magnesia	5.07	7.89	10.54	6.89	7.01
Iron Oxide	.33	2.16	.42	.48	.52
Phosphates	11.33	8.32	11.57	11.22	11.46
Sulphates	3.07	2.88	1.01	2.20	2.12
Chlorides	1.10	2.73	1.93	2.40	1.60
Carbonates	9.06	14.01	9.96	13.23	13.12
Totals	99.73	98.65	100.77	99.41	99.37

In table IV the separate composition of the leaves and stems for the first three periods is given. These figures illustrate the various points that have already been discussed in connection with the development of the clover plant.

TABLE IV.

COMPOSITION OF LEAVES AND STEMS OF CLOVER AT DIFFERENT STAGES OF GROWTH.

COMPOSITION OF THE DRY MATTER.

	First Period		Second Period		Third Period	
	Leaves	Stems	Leaves	Stems	Leaves	Stems
Ash	10.02	11.02	10.07	11.30	9.19	4.87
Ether Extract	.....	3.98	.....	4.95	.....	.....
Total Nitrogenous	30.68	13.44	27.38	11.25	19.37	11.26
Crude Fiber	10.48	18.46	10.51	26.32	15.36	35.27

COMPOSITION OF THE ASH.

Total Insoluble (sand)	3.55	9.0C	2.83	6.05	1.84	1.23
Potash	26.75	29.66	27.30	37.14	25.88	27.69
Soda	2.02	.94	1.24	2.26	1.06	.65
Lime	37.83	28.79	30.26	19.96	31.74	26.22
Magnesia	4.89	5.05	7.91	7.08	9.70	11.06
Iron Oxide	.61	.26	1.50	1.18	.24	.56
Phosphates	11.41	10.70	10.84	6.78	9.83	12.48
Sulphates	3.00	4.02	2.02	2.08	1.31	1.40
Chlorides	1.19	1.00	1.61	2.84	1.53	1.53
Carbonates	9.32	8.62	15.10	14.20	16.60	16.64
Total	100.57	98.10	100.61	99.57	99.73	99.46

In each of the above periods the per cent. of potash is greater in the stems than in the leaves, while the per cent. of lime is greater in the leaves. When in early bloom, the per cent. of total ash is greater in the leaves than in the stems. In *Wolff's Aschen-Analysen* these same points are to be observed, but the differences of potash and lime content in the stems and leaves are much greater than here recorded. In each period there is a gradual increase in carbonates which is due to a larger amount of the bases lime and potash being combined with organic acids. These organic acids upon combustion leave an increased amount of carbon dioxide.

CLOVER ROOTS.

Importance.—The roots and crop residue left by clover are of the greatest importance for keeping up the fertility of the soil. In Bulletin No. 30 of this Station the continuous cultivation of soils to grain crops was shown to result in reducing the amount of vegetable matter and humus in the soil. The loss of humus was followed by a loss of nitrogen, and a decreased power of the soil for retaining moisture and withstanding drought, as well as rendering some of the mineral matters, especially the phosphates, which are combined and associated with the humus, less valuable as plant food.

When the crop residue and roots of clover decompose they furnish organic matter which increases the humus in the soil, and the minerals which they contain are rendered available for the next crop that is not so able to obtain food from the soil as is the clover.

Fertilizer Constituents in Roots.—At full bloom, the amount of clover roots present from an acre of clover of 4000 pounds yield is approximately 1760 pounds, containing thirty-nine pounds of nitrogen, and 352 pounds of mineral matter composed in part of,

Potash	26.7 pounds
Phosphates	27.8 pounds
Lime	23.6 pounds

Fertilizer Value of Roots.—The nitrogen if purchased in the form of commercial fertilizers would cost $6.63. Since the experiments by Hellriegel and Weilfarth have shown that a large portion of this nitrogen comes from the free nitrogen of the air, a form which most farm crops are unable to make use of, a good share of this nitrogen may be counted

upon as a clear gain to the soil.

In addition to the fertilizer ingredients in the roots, the amount present in the stubble and crown must be added, which would make the total even larger. Leaving out this factor, which is a variable one, the figures as given show that the amounts would not be far from what could be expected of even a poorer crop of clover.

Value of Young Clover as Green Manure.—Had the young clover been plowed under for green manure at the first period, May 9, which would have been sufficiently early, in this latitude for planting corn, the amount of fertilizer ingredients furnished to the corn from an acre of the clover, including the roots, would have been:

	Plant.	Roots.	Total.
Dry Matter, pounds	324.	236.	560.
Nitrogen	12.	9.	21.
Phosphoric Acid	4.	2.5	6.5
Potash	10.	6.	16.
Lime	11.	12.	23.

VALUE.

21 pounds Nitrogen @ 15 cents per lb	$3.15
6.5 pounds Phos. Acid @ 6 cents per lb	.39
16 pounds Potash @ 4 cents per lb	.64
Total	$4.18

The clover plant, with its roots, at this period contained as much dry matter, phosphates, and potash per acre as there is present in a ton of good farm manure, and as much nitrogen as is in two tons of the best farm manure.

The important points regarding the value of clover roots, when fully developed, are:

1. An increase of 1500 to 2000 lbs. of organic matter to every acre of soil.

2. An increase of 30 to 50 lbs. of nitrogen per acre.

3. Changing 20 to 30 lbs. each of phosphates, potash and lime into more valuable forms of plant food.

Dry Matter in Roots.—During growth, the roots, at the different periods of their development show a marked change in composition. A gradual increase in dry matter is

to be observed. The amount of dry matter, in a square yard of the roots, at the different dates was:

First Period..... 122 grams of roots
Second Period..... 320 grams of roots
Third Period..... 916 grams of roots

Inasmuch as clover roots are of so much importance as a manure, their composition is given in the following table:

TABLE V.

COMPOSITION OF THE ASH OF CLOVER ROOTS.

	First Period	Second Period	Third Period
Potash	12.67	8.41	7.61
Soda	2.12	4.63	2.64
Lime	26.01	5.76	6.73
Magnesia	4.87	5.46	3.84
Iron Oxide	.40	2.95	1.67
Phosphates	5.55	11.28	7.87
Sulphates	2.39	4.86	2.12
Chlorides	1.16	2.12	3.16
Carbonates	4.02	2.12	.....
Total Insoluble	40.58	50.86	48.50
Total	99.77	98.45	

COMPOSITION OF DRY MATTER OF THE CLOVER ROOTS.

Ash	20.16	20.16	20.41
Ether Extract	4.11	3.89	2.47
Total Nitrogenous	23.61	16.70	13.81
Fiber	15.85	27.49	33.63

The Nitrogen in the Root Nodules.—The analysis of the dry matter of the clover roots at the third period showed 2.21 per cent. of total nitrogen. There are certain parts of the clover roots that are much richer in nitrogen than other parts. An examination of a healthy and well developed clover root will show little swellings known as root nodules. These root nodules are particularly rich in nitrogen. Analyses made in this laboratory show that they contain from four to six per cent. and more of nitrogen. In one case the light colored and active nodules contained 5.55 per cent. nitrogen, while the dark colored and older ones from the same plants contained 3.21 per cent. These small nodules were separated from the roots by the use of a scalpel. The work was very carefully done by Messrs. Hoverstad and Sandsten, members of the agricultural chemistry class of the

College of Agriculture. The mixed nodules, both active and inactive, from another lot of plants contained 4.60 per cent. nitrogen, while one hundred parts of the entire roots contained 2.21 parts of nitrogen.

These root nodules have been found to be the centres of action of definite and characteristic micro-organisms which transfer the free nitrogen of the air into forms which can be made use of by the plant. When these nodules cease to act the nitrogen and organisms which they contain, according to the investigations of Professor Marshall Ward, are distributed in the soil, which results in increasing the valuable nitrogen in the soil wherever clover has been grown.

In table VI analyses are given of red clover grown in different parts of the state. The first sample was grown in the southwestern part of the state at Camden, on the farm of Supt. Gregg. The clover grown at Rush City is in the northeastern portion of the state; Garfield, Douglas county, in the central western part, and Winnebago City in the southern central part of the state. Each sample of clover was grown on a different type of soil, and under as varied conditions of climate and exposure as one would expect to find in clover culture. The composition of the soil from these sections is given in Bulletin No. 30, and in the annual report of 1893. The greatest variations are shown in the amount of lime and potash that is present in the ash. The amount of nitrogenous material in the different samples is quite constant. The analysis of the ash does not show the want of any of the necessary elements, but rather an abundance, and gives no indication that any of these samples have suffered for the want of mineral food which the soil has failed to supply.

TABLE VI.

COMPOSITION OF CLOVER GROWN IN DIFFERENT PARTS OF THE STATE.

	Marshall.	Rush City.	Garfield.	Winnebago City.
Water	17.70	14.16	16.18	12.06
Dry Matter	82.30	85.84	83.82	87.94
COMPOSITION OF DRY MATTER.				
Ash	7.83	7.40	8.53	7.57
Ether Extract	3.85	3.82	3.12	2.95
Total Nitrogenous	12.87	12.96	13.20	12.83
Crude Fiber	27.44	29.34	23.45	27.03
COMPOSITION OF THE ASH.				
Insoluble (sand)	1.73	4.62	2.64	11.84
Potash	27.37	29.53	31.03	29.64
Soda	.75	1.12	.84	1.32
Lime	25.52	32.59	28.54	24.84
Magnesia	7.84	8.95	10.60	11.14
Iron Oxide	.34	.66	.44	1.10
Phosphates	13.07	9.16	10.12	7.10
Sulphates	3.20	1.74	2.13	1.33
Chlorides	1.41	.91	1.12	.86
Carbonates	18.24	10.30	10.86	9.75
Total	99.47	99.58	98.32	98.92

Another beneficial effect from clover has undoubtedly been observed by many farmers, that is, when clover is sown with timothy. A farmer in Southern Minnesota, says that one year he seeded clover and timothy, while his neighbor in an adjoining field planted timothy only. The line between the two fields was not well established, and when the fence was built, twenty feet of the timothy seeding came into the field with the timothy and clover. A marked difference could be observed between the height and yield of grass. For three or four years, even after the clover had all "run out," the timothy seeded with the clover was much superior in quality and gave a larger yield. The seeding of mixed clover and timothy is a favorite method with many farmers of the state.

SUMMARY

OF THE

CHEMICAL DEVELOPMENT AND VALUE OF RED CLOVER.

1. The failure of clover does not appear to be due to a deficiency of plant food in the soil, but is due more to the want of the proper mechanical conditions of the soil. These conditions can be ascertained only after extended experiments with the seeding of clover on different soils, and under different conditions.

2. Clover seeded with late wheat gave a yield of a ton per acre more than clover seeded with early oats. In both cases the clover was sown on fall plowed land which had previously been in corn for two years.

3. The largest yield of dry clover can be obtained at the end of flowering, while the largest yield of nitrogenous matter is from the time of full to late bloom.

4. At the time of full bloom, the nitrogenous materials in red clover have reached their most valuable food forms.

5. The lime and potash are taken up by the plant the most rapidly of any of the mineral matters. Only two per cent. of mineral matter is added to the crop after full bloom. No potash is taken up after full bloom, and when ripe the plant contains less potash than at the time of full bloom, which is due to the retrograde movement of the potash at maturity.

6. From fifty to sixty per cent. of the mineral matter taken from the soil by a clover crop is lime and potash; and in the way of fertilizers, clover responds the best to land plaster, which is a lime fertilizer, and wood ashes, which is mainly a potassium fertilizer.

7. The leaves of clover are very rich in nitrogenous compounds, from sixty to seventy per cent. of the entire amount

found in the plant, excepting roots, is in the leaves. About the same proportion of the lime is stored up in the leaves.

8. When the leaves are young and in the first stages of development they are the richest in nitrogen, on account of the nitrogenous compounds of the plant being developed at an earlier period than the non-nitrogenous compounds. The greatest change from lower (amido) forms of the nitrogen to the higher (proteid) food forms occurs from early to full bloom.

9. Clover roots are of much value for increasing the ferility of the soil by adding organic matter and nitrogen and changing phosphates, potash and lime into more available and valuable forms of plant food for succeeding crops.

10. At the time clover is five to six inches high, the plant, with its roots, if used for green manure, will contain as much dry matter, phosphates and potash per acre as there is in a ton of good farm manure, and as much nitrogen as there is in two tons of the best farm manure.

11. The clovers grown on different soils of the state, show the most variations in lime and potash, varying according to the nature and the amount in the soil. The clover in all cases has a practically equal food value.

12. The root nodules of clover contain from four to six per cent. of nitrogen. A crop of clover will add from thirty to fifty pounds, and more of nitrogen to every acre of land, and in addition to this, enough available mineral food will be left in the crowns and roots for two good crops of wheat.

II.—THE RUSSIAN THISTLE.

CHEMICAL ANALYSIS.

When the Russian thistle is young and tender, a very high food value is claimed for it by many sheep feeders, others claim that the sheep are attracted to the thistle, and relish it on account of the salt which it contains. As no analysis of the plant, grown under the conditions in which it now flourishes in this state, is to be found, a complete analysis of the ash and dry matter at different stages of its growth, was made. It was intended to obtain samples from different parts of the state, and accordingly a number of letters were sent out requesting samples for analysis. Most of the replies were to the effect that there were no thistles in the neighborhood, but "plenty of them in the next township" or "across the river." Fortunately for this work a liberal supply of the thistles are growing in what is known as the Midway Districts, between St. Paul and Minneapolis, where abundant material was obtained near at home.

Food Value.—The chemical analysis of the plant shows a very large amount of ash materials; in fact, nearly a fifth of the weight of the dry plant is mineral matter. This is an objection, as a fodder; but few agricultural plants contain ten per cent. or more of mineral matter, while most of the fodder crops contain a much less amount. A serious objection to its constant use as a fodder, is the large amount of mineral matter, of an alkaline nature, that is present.

One very favorable point, is the large amount of nitrogenous matter which it contains,—from twelve to seventeen per cent., as much as there is in clover or rape. From sixty-five to eighty per cent. of this nitrogen is in the valuable food form of protein, varying with the developement of the plant.

No examination was made to determine whether any of the remaining nitrogen was in the form of alkaloids or other injurious compounds.

Before the developement of the thorns there is not so much fiber, at which time it is more valuable as food, but it is still open to the serious objection of the abnormal amount of alkaline mineral matter. When ripe, the fiber (woody material) and mineral (earthy) matter, make up half of its composition. Although rich in nitrogenous matter it is associated with so much indigestible fiber and ash as to greatly lessen its food value.

COMPOSITION OF THE RUSSIAN THISTLE.

	Small and Tender	No Thorns	Thorns Out	Ripe
Water	82.65	78.59	.....	.....
Dry Matter	17.35	21.41	.....	.....

COMPOSITION OF THE DRY MATTER.

Ash	20.32	21.21	18.25	13.75
Ether Extract	3.91	3.18	2.97	3.77
Total Nitrogenous	17.78	14.71	13.45	12.34
Fiber	16.27	22.45	21.62	37.70
Nitrogen free extract	41.72	38.45	43.71	32.44
Total	100.00	100.00	100.00	100.00

Draft upon the Soil.—The separate composition of the ash shows that the weed has very strong foraging powers, and feeds upon the very best materials that are in the soil. There is a large amount of potash and lime taken up by the plant. From the small amount of silica (sand) present, the plant evidently does not feed upon the silicates, but takes large amounts of the very best materials from the soil.

The amount of sodium, one of the elements of common salt, is large compared with the amount found in agricultural plants, but not any more than is found in the alkali plants to which this is allied. The draft which the plant makes upon the sodium is a benefit to alkali lands, but with the beneficial loss of the sodium from these soils there is a serious loss of nitrogen, lime and potash, and to a less extent of phosphates.

The amount of sodium present in the plant is quite variable, indicating that the plant is capable to a certain extent of adapting itself to conditions where there is a less amount of alkali in the soil. This is generally followed by a diminished vigor of growth.

COMPOSITION OF THE ASH.

	Small and Tender	Thorns well out	Ripe
Total insoluable	1.93	2.43	3.95
Potash	26.82	31.21	27.36
Soda	9.16	4.25	12.46
Lime	26.37	24.55	22.39
Magnesia	9.66	7.66	5.56
Iron Oxide	.86	1.01	.85
Phosphates	3.49	4.00	3.11
Sulphates	1.52	1.26	4.39
Carbonates	19.28	20.25	17.34
Chlorides	.....	....	1.56
Total	.....	.....	98.97

From the time the thorns are out, until ripe, the thistle takes up a large amount of sodium from the soil, and only small amounts of other materials. The thistle makes its heaviest draft upon the soil before the thorns are well out, after that it takes but little of the essential plant food. To prevent the heavy draft of the thistle upon the soil, it should be destroyed while young. In the last stage of growth, the large amount of sodium taken from the soil is a benefit to strong alkali lands, but before this beneficial loss of sodium takes place, there is a serious loss of nitrogen, potash and lime.

An ordinary thistle of two pounds weight, covering a square yard, will take potash and lime than two good crops of wheat from the same area.

UNIVERSITY OF MINNESOTA.

Agricultural Experiment Station.

BULLETIN No. 35.

DAIRY DIVISION.

OCTOBER, 1894.

DAIRY HERD RECORD FOR 1893.
COST OF BUTTER PRODUCTION IN WINTER.
COMPARING PRAIRIE HAY WITH TIMOTHY.—REARING DAIRY CALVES.—CO-OPERATIVE CREAMERIES.
EXPERIMENTS IN SWEET CURD CHEESE WORK.

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.

EAGLE JOB PRINT, DELANO, MINN.

University of Minnesota.

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☞ The Bulletins of this Station are mailed free to all residents of the State who make application for them.

DAIRY HERD RECORD FOR 1893.

T. L. HÆCKER.

The unprecedented shrinkage in the price of wheat dur- the past few years, the heavy draft which it makes on the fertility of the soil and the uncertainty of the crop, has awakened in the minds of the people of the northwest a greater interest in dairying. Dairy husbandry covers a large field, embracing the kind of animal best adapted for dairying, selection, breeding, rearing and training of the young stock, their management, and the feeding value of the different grasses, grains and by-products of the mills, the best method of creaming milk, ripening and churning cream, and working, packing and marketing butter, and the manufacture of various kinds of cheese best adapted to our conditions, the organization of co-operative dairy associations, building, equipment and operation of creameries and cheese factories, with many other questions which bear upon this industry. The call for information has been so great and the lines of inquiry so varied that it was difficult to decide in which direction investigation should begin and if more has been undertaken than could be done well it is because of the great need; however, much of this work may be considered as simply preliminary.

One of the most important factors in dairying is the cost of butter production and to ascertain this the annual yield of milk and butter fat of each cow in the University Farm herd and cost of feed for each was the chief object of this record. No special effort was made to select an economical ration; the cows were fed bran, barley, corn, linseed meal, ensilage, roots and hay as had been the practice theretofore.

During the winter season the rations were adjusted to the appetite and power of assimilation of the cow, giving as much grain as each would eat regardless of size. During the summer enough grain was given to maintain a normal flow of milk. From the 1st of January to the 25th of February each cow received daily from twenty-four to forty pounds of ensilage, from three to five pounds of mixed hay, mostly timothy, six to ten pounds of wheat bran, and one to two pounds of linseed meal. From the 25th of February to the 7th of March each received from twenty-four to thirty pounds of ensilage, six to eight pounds of bran, five to six pounds of barley, one and a half to two pounds of linseed meal and three to five pounds of hay. During the remainder of March there was a reduction of two pounds of bran and a decrease in the amount of ensilage to about half of that fed in January. The ensilage was made from the two varieties of corn, "Pride of the North" and "White Dent," and was richer in ears than is usually the case. Toward spring much of it was of inferior quality owing to mould, and from this cause several of the cows were thrown off their feed and suffered a material shrinkage in milk and fat. During April they were fed from six to twelve pounds of old millet hay, which caused stomach disorders in several of the cows and proved fatal in one case, post mortem examination revealing impaction of the third stomach with millet seed. The cows were turned out to pasture the 17th of May, when the grain feed was gradually reduced and by the 1st of June it ranged from four to eight pounds of the mixture—bran, barley and linseed meal.

The feeding stuffs used have been found by analysis to contain the following per cent. of dry matter:

Hay, timothy	89.75	Ensilage	26.15
Hay, millet	92.35	Bran	89.60
Hay, prairie	89.15	Linseed meal	89.89
Barley meal	88.22	Squashes	14.72
Corn meal	89.27	Mangels	10.00

The average price per ton for the feed was found from statistics furnished by prominent farmers residing in different portions of the state and is believed to be a fair average valuation for the whole state:

	Per Ton.	Per lb. cents		Per Ton.	Per lb. cents.
Hay, timothy	$ 5.60	.28	Corn meal	$14.00	.7
Hay, prairie	3.20	.16	Linseed meal	26.00	1.30
Hay, millet	5.60	.28	Ensilage	2.00	.10
Hay, oat	4.80	.24	Bran	11.00	.55
Barley meal	14.00	.70	Mangels	2.00	.10
Oats	18.00	.90	Squashes	2.00	.10

Pasture, the season, $3.50.

The Grain Ration for each cow consisted of one part linseed meal, two parts barley, two parts corn meal and

TABLE VII.—Age of Cows and Date of Calving Prior to and During Experiment.

	Age.	Date of calving 1892.	Date of calving 1893.
Annie	6	July 10	August 4
Beckley	8	November 12	*July 10
Bess	9		February 15
Bettie	8	November 2	*September 1
Clara	7	June 13	*May 27
Dido	10		March 1
Dora	11	March 27	March 9
Fancy	7	March 21	May 6
Gertie	4	November 10	September 26
Houston	9	October 27	November 5
Jennie	5		November 27
Nora	3	November 20	*August 15
Olive	9	October 24	
Patsy	6	November 30	
Pride	10	February 15	May 22
Reddie	9	July 25	November 28
Rose	10		April 7
Rossy	5	April 16	*May 15
Roxy	8	October 16	*Aug. 10
Sully	9	October 16	*July 5
Sweet Briar	9	November 11	October 28
Topsy	7		February 22
Tricksey	9	October 21	December 14

*Aborted.

three parts wheat bran, or in cases where either barley or corn was omitted the other was increased pound for pound.

During the winter the cows were confined at night and a portion of the day in a basement, fastened with the Smith revolving stanchion which gives them more freedom than does the old rigid stanchion. Nearly all the cows are dehorned which made it possible to turn them a portion of each day into a large enclosed basement adjoining the stable, for water and exercise. During warm winter days they were occasionally turned into a yard.

In Table VII is given a list of the cows, approximate age, date of calving prior to and during the experiment and the number of days they were in milk during the year. It will be seen that a number of cows aborted; whether this increased or diminished the yield of milk and butter fat for the year is not known. It is apparent however that it had an injurious effect on a few that are somewhat inclined to lay on flesh, such as Beckley, Clara, Rossie and Sully. Bettie and her daughter Nora, with Roxy show but little, if any such disposition, or suffer an abnormal shrinkage in the flow of milk. The general plan was to have all cows calve in the fall. In some cases this was not carried out for various reasons. The cows were not all selected especially for the dairy as they were also to be used for illustrating purposes in the class room, where it is necessary to have fair representatives of the various types. Dido and Fancy do not belong to the dairy herd. The former is a full blood shorthorn of a milking family. Fancy is a full blood Polled-Angus but was transferred to the dairy for a year's trial, for the reason that in conformation she had some points which indicated fair dairy qualities. Rose and Sully are grade shorthorns. Rose is rather spare and angular while Sully belongs to the medium fleshy type. Most of the cows selected for the dairy were spare, deep in body, well developed spine and rump, sharp withers, steep at the crops, thin, rather long neck and face. At the time they were selected no information was solicited from or given by the owners, but each cow was selected because of the individuality she showed as a milk and butter giver. Neither was the Bab-

cock test resorted to except in case of Tricksey, and after three years' trial and severe pruning none of the cows so selected have, as yet, been culled out.

TABLE VIII..—Total Individual Yields of Milk and Fat.

Name.	Breed.	Days in Milk.	Lbs. of Milk.	Lbs. of Butter Fat.
Annie	Jersey	334	5,013.90	312.70
Beckley	Grade Jersey	365	4,948.30	300.98
Bess	Holstein Fresian	331	10,087.00	374.09
Bettie	Guernsey	365	4,957.90	267.67
Clara	Grade Jersey	365	4,952.80	241.92
Dido	Shorthorn	343	5,562.60	216.43
Dora	Jersey	346	6,515.90	353.86
Fancy	Polled Angus	363	5,992.00	261.71
Gertie	Grade Jersey	339	5,106.20	260.28
Houston	Jersey-Guernsey	320	6,976.10	366.98
Jennie	Grade Holstein	334	6,008.40	226.99
Nora	Jersey-Guernsey	365	4,526.00	225.46
Olive	Grade Guernsey	357	6,093.10	284.40
Patsy	Grade Jersey	365	6,284.20	293.09
Pride	Jersey	301	6,090.20	303.05
Reddie	Grade Guernsey	349	5,183.50	274.57
Rose	Grade Shorthorn.	266	7,337.70	296.38
Rossie	Grade Jersey	365	6,784.70	278.23
Roxy	Grade Jersey	365	7,546.30	358.42
Sully	Grade Shorthorn	365	7,066.00	318.01
Sweet Briar	Guernsey	336	7,094.30	357.62
Topsy	Grade Holstein	331	10,287.20	407.92
Tricksey	Guernsey	326	6,964.60	340.71
Average		343	6,407.78	300.93

In Table VIII. is given the names of the cows, the breed to which they belong, days in milk, the pounds of milk and fat produced. It was the aim not to resort to any estimates in this work when it was possible to get actual results.

Each milking was therefore weighed and recorded and a sample taken and tested by the Babcock test for per cent. of fat. In yield the grade Holstein-Friesian, Topsy, leads with

TOPSY.

10,287.2 lbs. of milk and 407.92 lbs. of fat. Bess, the full blood Holstein-Friesian follows with a record of 10,087 lbs. of milk and 374.09 lbs. of fat. The smallest yield of milk 4,526 lbs. was from the three year old heifer Nora. The smallest yield in butter fat was from the shorthorn Dido, 216 lbs. The only farrow cow in the herd was Fancy, the Polled-Angus and this fact should be borne in mind in comparing the amount and cost of her dairy product with others in the trial. Topsy carried a calf only a short time during the latter part of the year's work. Beckley, Clara, Rossie and Sully aborted quite early and were not bred until late in the autumn or early winter. The annual average yield of milk was 6407.78 pounds and average of fat 300.93 pounds including the two beef cows Fancy and Dido.

TABLE IX.—Weight of Cows, Average for Months and Year 1893.

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Aver'ge
Annie	774	770	775	787	804	874	888	826	834	846	854	.....	821
Beckley	945	943	950	973	968	1011	921	899	908	926	926	936	942
Bess	1215	1138	1058	1007	1006	1076	1159	1122	1147	1186	1201	1210	1127
Bettie	775	776	761	779	795	831	832	840	796	818	810	813	802
Clara	875	889	908	926	942	906	923	916	913	919	893	902	909
Dido	1267	1277	1225	1286	1174	1263	1273	1245	1225	1237	1232	1237	1245
Dora	907	898	894	853	809	843	838	839	836	853	854	883	859
Fancy	*1233	*1251	*1273	*1269	1313	1301	1301	1240	1221	1234	1224	1219	1256
Gertie	832	821	851	856	857	898	911	951	973	865	871	878	880
Houston	920	928	909	896	900	927	953	954	952	1004	924	900	931
Jennie	915	926	963	994	977	1023	1040	1057	1074	1125	1119	1031	1020
Nora	783	801	806	814	839	869	889	861	819	827	828	846	832
Olive	752	731	766	735	758	789	801	810	820	863	918	915	805
Patsy	827	807	796	795	803	911	927	902	901	935	931	934	872
Pride	758	781	697	705	736	780	783	770	773	773	773	771	758
Reddy	994	968	981	956	971	1029	1051	1036	1074	1107	1141	1018	1027
Rose	1212	1251	1272	1135	1017	1122	1148	1110	1079	1071	1081	1135	1136
Rossie	838	820	864	862	906	931	940	942	941	942	946	898	903
Roxy	975	921	921	942	931	1004	1035	971	971	973	968	972	965
Sully	1268	1272	1291	1307	1299	1321	1186	1130	1121	1138	1148	1141	1219
Sweet Briar	956	926	915	927	941	1001	1025	1060	1059	1118	1031	1040	1000
Topsy	1249	1266	1086	1020	991	1070	1078	1107	1054	1129	1101	1060	1101
Tricksey	902	912	890	911	935	951	951	967	984	1004	1038	1095	962

The figures marked thus (*) are for 1894.

TABLE X.—Milk Record, Monthly and Total for Each Cow.

NAME.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Annie	386.8	347.0	399.1	360.1	329.7	285.3	25.8	688.9	654.6	545.4	575.3	466.1	5,013.9
Beckley	528.3	488.0	470.5	454.3	476.5	499.1	286.7	404.2	410.7	378.1	296.7	255.2	4,948.3
Bess	225.9	455.2	1,431.8	1,114.5	1,087.6	1,172.8	1,066.7	977.5	948.7	833.0	584.0	189.2	10,087.0
Bettie	579.8	451.8	488.5	440.0	430.5	438.8	414.6	415.1	338.7	352.4	317.1	290.6	4,957 9
Clara	371.2	334.4	373.5	330.1	282.3	499.7	567.4	558.7	453.1	472.1	385.6	324.7	4,952.8
Dido	*189.1	*10.6	720.7	610.6	535.6	687.1	715.1	497.1	464.2	465.7	440.2	326.6	5,562.6
Dora	*266.8	*69.8	695.0	848.9	765.5	767.4	712.9	601.0	557.7	458.0	415.7	357.2	6,515.9
Fancy	*337.2	*254.7	303.5	*271.8	725.1	891.9	559.1	616.0	550.5	485.8	431.8	365.6	5,992.0
Gertie	584.3	492.0	505.1	428.2	439.8	437.2	310.1	33.0	.....	662.6	615.6	598.3	5,106.2
Houston	807.7	668.9	708.3	592.2	617.1	693.8	608.0	485.2	255.3	.....	705.6	834.0	6,976.1
Jennie	546.1	489.8	604.6	552.6	617.0	676.7	513.1	471.8	383.3	125.7	37.7	990.0	6,008.4
Nora	422 8	347.4	366.4	328.6	368.3	388.0	344.2	351.2	384.5	417.2	415.8	391.6	4,526.0
Olive	771.3	623.3	647.4	500.7	519.6	598.1	571.5	527.2	461.5	398.5	327.4	146.6	6,093.1
Patsy	862.8	659.9	621.7	501.2	541.1	653.9	541.3	481.7	406.1	426.5	344.5	243.5	6,284.2
Pride	467.2	448.9	127.1	.....	243.2	915.8	851.3	748.6	634.8	606.6	555.6	491.1	6,090.2
Reddie	537.5	381.1	409.7	351.3	421.7	542.7	463.6	401.2	328.1	286.0	127.7	932.9	5,183.5
Rose	.....	.....	.....	709.0	1,069.4	1,067.2	968.8	849 1	755.4	649.0	605.3	664.5	7,337,7
Rossie	498.7	479.1	525.0	467.4	502.9	713.1	690.7	656.1	608.4	593.6	561.3	488.4	6,784.7
Roxy	854.0	652.1	682.4	608.5	646.6	788.7	577.7	451.7	577.0	639.2	565.3	503.1	7,546.3
Sully	561.4	517.9	552.6	520.7	518.4	398.6	502.8	711 4	713.8	696.5	713.4	658.5	7,066.0
Sweet Briar	826.5	686.2	649.7	613.2	653.5	765.8	689.4	562.2	437.6	57.2	594.1	558.9	7,094.3
Topsy	175.3	132.0	1,407.6	1,184.2	1,064.8	1,121.0	1,067.2	936.0	850.4	756.7	761.4	830.6	10,287.2
Tricksey	806.9	669.0	727.0	625.7	660.4	766.7	699.3	583.8	492.7	317.2	72.5	442.7	6,964.6

The figures marked thus (*) are for the year 1894.

For the dairy herd proper, the average annual milk yield was 6,467.80 pounds, and butter fat 306.83 pounds.

The cows were weighed every Monday morning after milking and feeding and before they were allowed to drink. Little change took place in the weight of the cows during the year. Sweet Briar gained 84 pounds and Jennie gained 116. Nora and Gertie made some growth during the year. The scales afford but little assistance in our efforts to convey to the reader a proper conception of the size of the cow. A small cow compactly built and carrying considerable flesh may weigh as much or more than one with a large frame, lean and loosely built.

In the last annual report of this station it appears that there were ten cows in the herd weighing over one thousand pounds; of these three do not appear in this year's record, having been culled out. In table X. are eight cows weighing over a thousand pounds each and three of these will be discarded for want of merit.

TABLE XI.—Per Cent Fat—Average per Month and Year.

NAME.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average
Annie	7.06	7.00	6.70	6.89	7.17	6.85	7.50	4.72	5.59	5.91	6.16	6.26	6.48
Beckley	6.45	6.42	6.16	6.39	6.52	6.17	6.26	5.59	5.58	5.80	5.88	6.37	6.13
Bess	4.66	4.58	3.82	3.85	3.72	3.43	3.56	3.65	3.78	3.48	3.56	3.92	3.83
Bettie	4.87	4.87	5.00	5.49	5.56	5.18	5.41	5.63	5.41	5.66	5.55	6.26	5.41
Clara	5.32	5.05	4.87	5.30	5.63	4.59	4.49	4.57	4.64	4.51	4.42	4.96	4.86
Dido	*4.43	*4.10	3.65	4.12	4 20	3.79	3.86	3.89	4.26	3,83	3.84	3.85	3.99
Dora	*6.97	*7.16	4.77	4.92	5.48	5.21	4.97	5.27	5.22	5.87	6.11	6.65	5.72
Fancy	*4.93	*5.07	4.26	4.47	4.00	3.72	4.14	4.36	4.66	4.52	4.35	4.70	4.43
Gertie	5.42	5.20	4.78	5.03	5.07	4.94	5.75	6.00	.....	4.90	4.90	4.99	5.18
Houston	5.41	5.32	5.15	5.12	5.08	5.00	5.42	5.51	5.37	.....	4.76	5.31	5.22
Jennie	3.71	3.44	3.19	3.44	3.63	3.45	4.19	4.35	4.57	4.49	3.29	3.78	3.79
Nora	4.95	5.20	4.92	5.39	5.23	4.88	5.33	5.15	4.87	4.72	4.51	4.88	5.00
Olive	4.55	4.48	4.64	4.77	4.54	4.44	4.57	4.59	4.84	4.91	5.26	5.84	4.79
Patsy	4.49	4.23	4.39	4.73	4.82	4.65	4.71	4.84	4.91	4.70	4.68	5.36	4.71
Pride	5.78	5.51	6.40	.....	4.17	4.58	4.56	4.86	4.96	5.00	5.23	5.46	4.71
Reddie	5.63	5.94	5.73	5.59	5.08	4.70	5.15	5.36	5.59	5.80	.....	4.92	5.41
Rose	.....	.....	.....	3.85	3.73	3.90	4.10	4.16	4.46	4.29	4.36	4.82	4.19
Rossie	4.23	4.02	4.13	4.38	4.39	4.03	4.07	4.01	4.17	3.88	3.69	4.16	4.10
Roxy	4.65	4.71	4.60	4.74	4.88	4.68	5.00	5.28	4.85	4.45	4.52	4.89	4.77
Sully	4.65	4.43	4.35	4.70	4.89	4.87	5.00	4.23	4.59	4.20	3.88	4.51	4.53
Sweet Briar	5.03	4.97	5.14	4.98	5.15	5.15	4.98	5.24	5.55	.....	4.54	5.15	5.08
Topsy	5.00	4.10	3.83	3.93	4.00	4.15	3.96	4.03	4.13	4.31	3.68	3.85	4.08
Tricksey	4.68	4.85	4.76	4.77	4.69	4.47	4.58	4.79	5.26	5.60	.....	4.27	4.79

The figures marked thus (*) are for the year 1894.

TABLE XII.—Total Butter Fat for each Cow for each Month and for the Year.

NAME.	Jan.	Feb.	March.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	For Year
Annie	27.13	24.01	26.80	25.11	23.49	19.77	2.11	31.25	36.21	35.28	31.98	29.56	312.70
Beckley	34.23	29.00	28.98	29.14	30.33	30.68	18.01	22.74	22.47	22.02	17.21	16.17	300.98
Bess	9.78	20.61	54.37	42.93	39.66	40.16	37.99	35.72	35.89	29.01	20.49	7.48	374.09
Bettie	28.04	22.12	24.59	24.31	23.98	23.57	23.14	23.20	18.54	20.15	17.54	18.49	267.67
Clara	19.70	16.96	18.31	17.80	17.02	23.16	25.62	25.79	22.85	21.51	16.89	16.31	241.92
Dido	*8.19	*.44	25.88	25.32	20.22	25.65	23.79	19.45	20.20	17.97	16.55	12.77	216.43
Dora	*18.63	*5.01	32.05	41.77	42.47	40.61	35.45	32.13	29.30	27.16	25.30	23.98	353.86
Fancy	*16.83	*13.04	*13.19	*12.30	30.06	33.06	31.56	27.49	25.84	22.13	18.71	17.50	261.71
Gertie	31.57	25.59	24.30	21.65	22.53	21.74	18.49	1.99	.....	32.48	29.96	29.98	260.28
Houston	44.98	36.58	36.49	30.52	31.41	35.22	33.28	26.72	14.99	.....	32.67	44.12	366.98
Jennie	20.19	16.73	19.35	19.21	22 78	23.34	22 66	20.75	17.74	5.66	1.15	37.43	226.99
Nora	20.88	17.74	18.23	17.00	19.37	19.19	18.60	18.00	18.92	19.77	18.58	19.23	225.46
Olive	34.15	28.05	30.48	23.98	23.57	25.88	26.31	24.45	22.01	19.81	17.08	8.63	284.40
Patsy	38.35	27.71	27.14	23.75	26.69	30.88	25.23	23.65	20.22	20.25	15.98	13.24	293.09
Pride	26.23	23.84	8.31	.....	10.22	42.18	38.96	35.82	31.09	30.64	28.86	26.90	303.05
Reddie	29.63	22.30	22.65	19.58	21.61	25.69	24.00	21.70	18.44	16.42	6.69	45.86	274.57
Rose	.....	.....	.....	27.25	39.79	43.63	39.74	36.05	33.61	27.66	26.00	22.65	296.38
Rossie	21.38	19.49	21.52	21.11	22.25	28.78	28.07	26.26	25.41	23.02	20.71	20.26	278.23
Roxy	40.03	30.64	31.23	28.88	31.42	37.17	29.12	23.86	27.89	28.68	25.10	24.40	358.42
Sully	26.13	23.91	23.96	24.67	24.79	19.70	25.73	29.87	32.75	29.17	27.61	29.72	318.01
Sweet Briar	41.25	34.15	33.23	30.22	33.78	37.01	34.41	30.14	25.00	2.83	26.73	28.87	357.62
Topsy	8.32	4.82	53.71	47.30	42.35	45.72	42.14	37.78	35.23	29.84	28.65	32.06	407.92
Tricksey	37.48	32.08	34.24	29.98	30.90	33.88	32 25	28.03	26.10	27.78	3.84	24.15	340.71

The figures marked thus (*) are for the year 1894.

Table XII. gives the yield of milk of each cow in pounds, each month in the year, and shows a remarkable persistency in the flow of milk, though this feature cannot be taken into account with Beckley, Bettie, Clara, Nora, Rossie, Roxy and Sully, as they aborted during the trial, and also Fancy, as she was not in calf during the year, which doubtless caused her to give a larger yield than she would have done under normal conditions.

Annie left the herd in Nov. 1893, so her record for Nov. and Dec. 1892 is given to complete the year. Dido and Dora calved in March and to complete the year's record for them it is carried over into 1894, the requisite length of time. The same would have been done with Rose had she been in milk during that period; she goes dry about three months of the year. Fancy's record commences with May, 1893 and ends May 1st, 1894. The amount of milk given by a cow or the cost of milk alone gives but little data of practical value for the reason that there is such a marked difference in the quality of the milk from different cows.

By comparing tables X. and XI. it will be seen that the milk from the cows giving a large flow contains a small percentage of fat while the milk from those giving a small quantity is relatively rich in fat. Annie's milk contained the largest percentage of fat up to August when she calved and the quality of the milk dropped nearly two per cent. The next in quality is Beckley with an average of 6.13 per cent. fat. The average per cent. for the Jerseys and their grades is 5.3; for the Holstein Friesian and grades it is 3.9, the Guernseys and grades average 5 per cent, and the shorthorns and grade shorthorns 4.2 per cent. There seems to be a general tendency for the milk to get richer as the period of lactation advances, yet there are so many variations that it is exceedingly difficult to account for them all. During the first half of June there was a marked decrease in the per cent. fat, while for the remainder of the month the increase was equally as marked. So far there is no indication that feed produces any great change in the quality of milk. Succulent feed slightly increases the volume of milk and consequently decreases the per cent. fat, while a change to dry feed decreases the flow

which results in an increased per cent. fat. The daily variation in the quality of milk is greater than the daily variation in quantity, but taking longer periods, such as a month or more, the variation appears to be reversed.

The herd as a whole is composed of cows light in weight, the two most marked exceptions being Dido and Fancy, which are heaviest, though not as large as Bess and Topsey. Next in size and weight are Sully and Rose, the grade shorthorns. If we exclude the two beef cows, Dido and Fancy, (which do not belong to the dairy herd proper) the average weight is 947 pounds.

As will be seen by Table XIII. all the feed consumed by each cow, and time in pasture during the year, is charged to her account. This seems to be the proper thing to do, for a cow must be maintained during the time when she goes dry be it long or short. If she is a good dairy cow the period will be comparatively short. Sully, the grade shorthorn, consumed the most feed, which cost $43.98; Bess follows next with $43.52; then Topsy $42.56; Sweet Briar $42.34; Houston $41.22 and Roxy $41.01. All the others were under $40 and over $32 with an average for the herd of $37.82. The amount of milk and cost per 100 pounds is a matter of little moment on account of the wide variation in the per cent. of fat and other solids contained in different milks. The grade Holstein, Topsy, produced the largest amount of butter fat for the year; she also produced it at the least cost, 10.4 cents per pound. Judging from her conformation, her quality individually, the richness of her milk and the fact that many of the cows in the neighborhood, where she was bred, have an infusion of Jersey, it is suspected that she has some Jersey blood in her veins. The fact that the full blood cows Dora and Annie came from the same herd and that other cows in the herd are grade Jerseys, and that it is not known which cow was her dam, makes her blood lines a matter of uncertainty. It is known, however, that her sire was a Holstein-Friesian.

TABLE XIII.—Feed Consumed by Each Cow.

NAME.	Bran.	Barley.	Corn.	Linseed Meal.	Roots.	Ensilage.	Hay.	Pasture. (Days.)
Annie	1938.87	952.68	254.75	482.36	1718.40	3561.00	1960.50	130.50
Beckley	1806.64	874.77	345.90	450.93	1870.00	4702.00	1962.00	130.50
Bess	2002.53	1156.32	351.59	551.85	1780.00	3644.00	2329.00	130.50
Bettie	1528.67	800.05	252.78	384.28	1780.00	3920.00	1688.50	130.50
Clara	1569.21	831.41	258.94	396.53	1745.00	4060.00	1740.00	123.50
Dido	1331.38	796.89	265.02	341.65	1745.00	3662.00	1824.00	130.50
Dora	1729.92	894.58	434.27	446.23	1780.00	3046.00	2050.00	130.50
Fancy	1560.69	886.18	602.37	426.92	1780.00	1506.00	2569.00	135.50
Gertie	1496.09	739 29	349.19	382.75	1800.00	3916.00	1649.50	130.50
Houston	2064.09	840.40	306.81	546.86	1640.00	4180.00	2150.00	130.50
Jennie	1824.74	988.87	321.36	467.32	2517.00	3630.00	1749.50	130.50
Nora	1558.70	815.31	268.04	393.24	1780.00	3906.00	1688.50	130.50
Olive	1651.48	912.69	288.82	359.50	1870.00	2470.00	2259.60	130.50
Patsy	1615.87	741.35	231.78	402.48	1780.00	3336.00	1970.50	130.50
*Pride	1446.17	968.74	691.56	441.93	1835.00	1918.00	2039.00	130.50
Reddie	1646.59	816.89	331.42	420.39	1780.00	4094.00	1725.40	130.50
Rose	1755.64	753.24	482.83	449.02	1780.00	1768.00	2191.00	130.50
Rossie	1544.19	777.62	312.25	390.85	1870.00	3138.00	1644.50	130.50
Roxy	1979.65	898.98	383.77	499.87	1870.00	3564.00	2266.40	130.50
Sully	2113.10	1083.59	346.78	525.55	1780.00	5272.00	1998.00	130.50
Sweet Briar	2088.28	816.43	390.84	553.54	1870.00	3940.00	2334.00	130.50
Topsy	1965.71	1123,50	360 77	542.34	1780.00	3344.00	2266.00	130.50
Tricksey	1985.59	720.73	403.14	520.25	1860.00	3450.00	2612.00	130.50

*Pride, during June and July received 68 pounds of oats, value of oats is included in cost.

Hay consists of Timothy, Oat and Millet; and prairie hay for Dido, Dora and Fancy half the time during the months of Feb., March and April.

TABLE XIV.—Cost of Feed and Dairy Products,

NAME.	Weight of cow.....	Cost of feed	Lbs. of milk...	Cost of 100 pounds milk...	Pounds of butter fat.....	Cost of 1 lb. of butter fat.	Pounds of butter.....	Cost of 1 pound butter.	Pounds of butter per 100 pounds live weight.....
				cents		cents		cents	
Annie	821	$39.10	5013.90	77.9	312.70	12.4	379.03	10.3	46.17
Beckley	942	39.24	4949.30	79.3	300.98	13.1	364.82	10.8	38.73
Bess	1127	43.52	10087.00	43.1	374.09	11 6	453.40	09.6	40.24
Bettie	802	34.04	4957.90	68.7	267.67	12.7	324.40	10.5	40.45
Clara	909	34.79	4952.80	70.2	241.92	14.4	293.20	11.8	32.25
Dido	1302	32.13	5562.60	57.8	216.43	14.8	262.30	12.2	20.14
Dora	877	37.58	6515.90	57.7	353.86	10.6	428.90	08.8	48.91
Fancy	1259	37.07	5992.00	61.9	261.71	14.2	317.20	11.7	25.24
Gertie	880	34.07	5106.20	66.7	260.28	13.1	315.50	10.8	35.85
Houston	931	41.22	6976.10	59.1	366.98	11.2	444.80	09.3	47.78
Jennie	1020	39.19	6008.40	65.2	226.99	17.3	275.10	14.2	26.97
Nora	832	34.52	4526.00	76.3	225.46	15.3	273.30	12.6	32.87
Olive	805	35.69	6093.10	58.6	284.40	12.5	344.70	10.4	42.82
Patsy	872	34.44	6284.20	54.8	293.09	11.7	355.10	09.7	40.72
Pride	758	38.26	6090.20	62.8	303.05	12.6	367.30	10.4	48.45
Reddie	1027	36.27	5183.50	70.0	274.57	13.2	332.80	10.9	32.40
Rose	1136	36.73	7337.70	50.1	296.38	12.4	359.20	10.2	31.62
Rossie	903	33.72	6784.70	49.7	278.23	12.1	337.20	10.0	37.34
Roxy	965	41.01	7546.30	54.3	358.42	11.4	434.40	09.4	45.02
Sully	1219	43.98	7600.00	62.2	318.01	13.8	385.50	11 4	31.62
Sweet Briar	1000	42.34	7094.30	59.7	357 62	11.8	433.50	09.8	43.35
Topsy	1101	42.56	10287.20	41.4	407.92	10.4	494.40	08.6	44.90
Tricksey	962	40.71	6964.60	58.5	340.71	11.9	412.98	09.8	42.92
Total	22448	872.18	147378.91	1406.6	6921.47	294.7	8362.7	243.3	
Average	976	37.82	6407.78	61.1	300.93	12.8	364.6	10.6	38.12
Averages without Dido and Fancy	947	38.23	6467.80	61.2	306.93	12.7	371.9	10.4	39.59

Dora gave 353.86 lbs. of fat costing 10.6 cents per lb., she was, however, at a disadvantage as she carried a calf six months of the test while Topsy was in calf only a short time during the year. Eleven of the cows average 344.04 lbs. butter fat and the herd with Dido and Fancy average 300.93, while the dairy herd proper averages 306.83 lbs. In examining further, table XIV. it will be seen that there are excellent cows among all the breeds represented in the Station herd; it also appears that among the best can be found large cows as well as small ones; large in this sense does not mean heavy in weight but has reference to size only.

The average cost of 100 lbs. of milk was 61.2 cents. The average cost of a pound of butter fat for the herd was 12.8 cents. If all the cows in the herd that are spare and will not lay on flesh under heavy feeding are placed in one group and those that carry a superfluous amount of flesh in another group, we find the cows that give the largest returns for food consumed, in the first lot and in every instance, those that give a smaller return, in the other lot. The spare cows average 337.1 lbs. of butter fat at a cost of 11.6 cents per lb. while the cows that are inclined to put on flesh average 267.8 lbs. of fat at a cost of 13.8 cents per lb. It should be stated in justice to Beckley and Sully, that under normal conditions one or possibly both would be classed in the spare group. At the time of dropping their calves the placenta was removed from these two by artificial means, while in the other cases nature was allowed to take its course. These two shrunk materially in their milk and were out of condition a couple of weeks.

In Table XIV. is given also the number of pounds of butter and its cost per pound assuming that each .825 of a bl. of fat in the milk will make a pound of butter allowing for losses in skim and butter milk. The average amount of butter per cow for the entire herd for the year was 364.6 lbs. Taking out the two beef cows the average for the remainder of the herd was 371.9 lbs. being a trifle over one pound of butter per day for each cow. The average cost for feed per day for each cow was 10.4 cents. In examining Table IX. it should be borne in mind that the cows were charged a uniform price for pasture as it was impossible to ascertain how much grass each cow consumed, consequently the cost of butter fat for the summer may not be absolutely correct, though the errors, if any, are slight.

Further investigation will be made on this subject with a view of arriving at some definite conclusions as to the type of cow best adapted for the dairy.

TABLE XV.—Cost of One Pound of Butter Fat by Months.

NAME.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Annie	.130	.124	.131	.145	.145	.103	.100	.112	.097	.135	.119	.124
Beckley	.124	.136	.173	.143	.129	.076	.105	.121	.118	.124	.180	.184
Bess	.223	.066	.103	.115	.100	.062	.062	.096	.088	.128	.195	.406
Bettie	.122	.135	.143	.149	.142	.086	.082	.118	.139	.135	.155	.116
Clara	.172	.176	.222	.204	.184	.086	.074	.106	.098	.125	.184	.183
Dido	.257	.182	.192	.143	.156	.078	.079	.141	.108	.150	.184	.234
Dora	.170	.365	.074	.100	.091	.060	.066	.099	.093	.120	.140	.143
Fancy	.187	.263	.307	.316	.086	.068	.074	.110	.103	.143	.170	.170
Gertie	.097	.116	.167	.168	.140	.092	.086	.131	.....	.100	.114	.132
Houston	.090	.107	.122	.141	.126	.060	.063	.113	.116	.....	.092	.090
Jennie	.169	.178	.227	.217	.172	.107	.103	.155	.154	.525	.261	.100
Nora	.164	.168	.193	.214	.176	.107	.102	.152	.138	.134	.164	.158
Olive	.099	.120	.122	.179	.152	.080	.072	.112	.117	.134	.181	.251
Patsy	.089	.108	.140	.155	.129	.066	.075	.116	.111	.135	.167	.214
Pride	.120	.230	.251	.....	.079	.060	.071	.100	.099	.114	.142	.129
Reddie	.133	.141	.194	.185	.157	.080	.079	.113	.122	.166	.205	.081
Rose	.....	.....	.....	.088	.079	.041	.059	.084	.081	.115	.147	.175
Rossie	.120	.153	.164	.172	.156	.070	.067	.093	.089	.120	.153	.147
Roxy	.100	.103	.142	.149	.126	.070	.065	.132	.095	.112	.154	.161
Sully	.160	.170	.212	.200	.160	.110	.110	.106	.083	.112	.145	.133
Sweet Briar	.130	.115	.134	.143	.117	.070	.068	.105	.104	.085	.146	.137
Topsy	.304	.137	.089	.100	.094	.050	.055	.091	.089	.124	.139	.124
Tricksey	.114	.123	.130	.144	.128	.071	.072	.113	.100	.054	.117	.....
Average	.149	.151	.165	.162	.132	.076	.078	.114	.106	.140	.159	.164

COST OF BUTTER PRODUCTION IN WINTER.

T. L. HÆCKER.

The object of this experiment was to ascertain with greater accuracy, the cost of butter fat for the winter months when all the conditions are more under control than during the summer. Each cow was charged with all the feed consumed and credited with her yield of milk and fat. It was found impossible to make the trial the same length for each cow for the reason that they were not all at the same time in a condition which would make it fair, so each cow was placed on trial at a time when it was thought she would do herself justice.

A careful record was kept of the amount of feed taken by each cow, and a chemical analysis made of all the feed stuffs used. The cost of the feed was calculated upon the same basis as it was in the yearly feed record. Each milking was weighed and tested by the Babcock test, so the results are actual, no estimates being resorted to in any part of the work. The average weight was ascertained by weighing each cow every Monday morning after feeding and before watering, dividing this sum by the number of weeks each cow was in the trial.

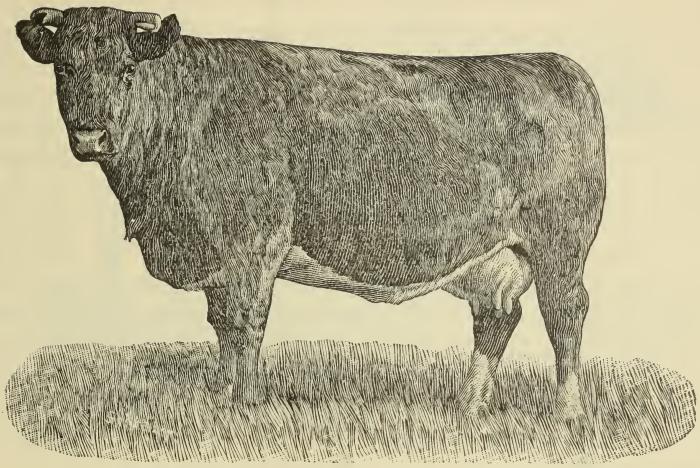
To explain the headings below the columns in Table XVI. it may be well to state that the first gives the names of the cows in the trial, the second, average weight of each cow; third, the number of days each cow was in the trial; fourth the total pounds of dry matter eaten; fifth, the average number of pounds of dry matter taken per day; sixth, the number of pounds of dry matter taken daily per one thousand pounds of live weight; seventh, pounds of butter fat produced during the trial; eighth, butter fat produced per day; ninth, pounds of dry matter required for each pound of butter fat; tenth, cost of a pound of butter fat; eleventh,

TABLE XVI.—Summary of Results Obtained.

NAME.	Avge. Weight ..	Days on Trial..	Dry Matter in Food	Dry Matter per Day	Dry Matter per 1000 lbs. live Weight	Total Butter Fat.....	Butter Fat per Day.....	Dry Matter for 1 lb. Butter Fat	Cost of 1 lb. of Butter Fat....	Butter Fat per Day per 1000 lbs. live weight
	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cents.	
Annie	787	152	3095.53	20.37	25.80	142.78	.939	21.68	12.8	1.193
Beckley	941	121	2864.41	23.67	25.15	143.37	.944	25.08	14.3	1.000
Bess	1134	154	3772.88	24.60	22.04	177.19	1.150	21.29	12.3	1.014
Bettie	787	181	3323.37	18.36	23.33	136.75	.756	24.30	13.8	.960
Clara	902	181	3455.82	19.09	21.16	111.26	.614	31.05	17.8	.680
Dido	1277	184	3452.24	18.76	14.61	106.88	.579	32.36	18.2	.453
Dora	874	142	2771.59	19.52	22.33	150.26	1.058	18.44	11.1	1.211
Fancy	1232	151	2863.97	18.97	15.41	88.21	.584	32.47	18.1	.474
Gertie	849	181	3565.21	19.70	23.20	165.55	.915	21.53	12.3	1.078
Houston	911	151	3884.53	25.73	28.24	192.69	1.276	20.16	10.8	1.401
Jennie	966	151	3222.39	21.34	22.09	112.91	.747	28.58	16.6	.773
Nora	815	181	3339.05	19.00	23.31	112.15	.620	29.77	17.2	.761
Olive	854	181	3647.05	20.15	23.59	153.55	.848	23.75	13.4	.993
Patsy	849	181	3411.08	18.85	22.20	153.18	.846	22.27	12.6	.996
Pride	771	151	2890.74	19.14	24.82	136.47	.904	21.18	12.6	1.172
Reddie	1004	182	3823.92	21.10	21.02	156.44	.859	24.44	13.8	.857
Rose	1106	112	2213.99	19.76	17.87	103.56	.924	21.37	12.9	.835
Rossie	1054	181	3196.09	17.66	16.75	127.23	.703	25.12	14.6	.667
Roxy	950	181	4043.03	22,34	23.52	184.56	1,197	21.91	12.4	1.260
Sully	1237	181	4469.19	24.69	19.96	154.45	.853	28.94	16.4	.689
Sweet Briar	966	181	4483.09	24.77	25.65	194.45	1.074	23.06	12.8	1.112
Topsy	1108	174	4005.00	23.17	20.91	199.88	1,148	20.04	12.0	1.036
Tricksey	924	138	3373.37	24.45	26.46	161.56	1.170	20.88	11.4	1.266

pounds of butter fat produced daily per thousand pounds of live weight. Every cow in the herd was in the trial, and by referring to Table VIII. the breeding of each cow may be seen. In noticing the average weight of the cows it should be borne in mind that the weight of a cow does not convey a correct idea of her size. Neither Dido nor Fancy are as large as their weight would indicate. The same is true of Beckley, Clara and Rossie, while Topsy, Jenny. Bess and Bettie are larger than one would suppose, judging from their weight. The variation in amount of dry matter consumed per day by different cows is much larger than is generally supposed. In order to make comparison, the feed consumed is figured on a basis of one thousand pounds live weight. Houston consumed an average of 28.24 pounds per day, Dido took only 14.61 pounds per day, Fancy following next with 15.41 pounds. Not only are these two cows light feeders, but it also appears from the foregoing table, that they gave a small return for the feed consumed. Fancy gave only one pound of butter fat for every 32.47 pounds of dry matter eaten, Dido required 32.36 pounds for each pound of butter fat, while the smaller cows, Houston and Dora, required only 20.18 and 18.44 pounds respectively, and the large framed cow, Topsey, required only 20 04 of dry matter for a pound of butter fat. From this, it seems the line cannot be drawn between good and poor cows on their size, neither can it be drawn on breeds; for example, take the two shorthorns, Dido and Rose, the former requiring 32.36 pounds of dry matter for a pound of butter fat, to 21.37 pounds for Rose. The grade Holstein, Jennie, takes 28.58, while the grade Holstein, Topsy, is charged only 20.04. The Jersey, Beckley, takes 25.08 and the Jersey, Dora, takes only 18.44.

It is evident then that some cows produce butter fat much cheaper than others, the variation being so great that under certain conditions one class will produce it at a profit and another at a loss. If the cows are divided into four groups based on conformation, assigning the beefy cows to the first those with less tendency to plumpness to the second, the spare, cows lacking depth to the third and the spare cows with deep bodies to the fourth, results follow which seem to be of vital importance to every dairyman.



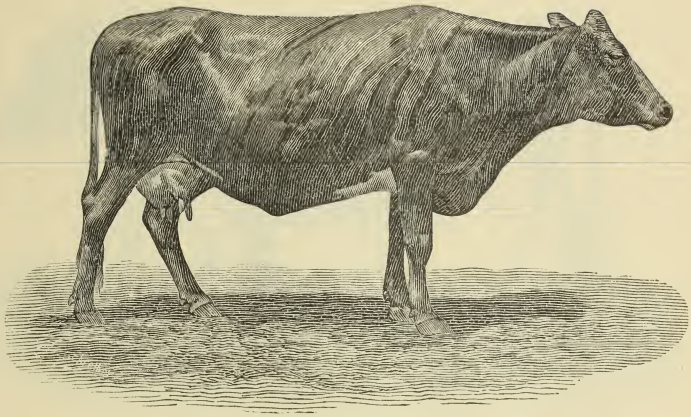
DIDO.

TABLE XVII. GROUP I.—Beef Type, ocky and Plump.

Cow.	Weight.	Breed.	Lbs. Dry Matter per day per 1000 lbs. live weight	Lbs. dry matter for 1lb. of butter fat	Lbs. butterfat from 100lbs. of dry matter	Cost of 1lb of butter fat
						cents.
Fancy	1256	Polled Angus	15.41	32.47	3 08	18.1
Dido	1245	Shorthorn	14.61	32.36	3.09	18.2
Sully	1219	Shorthorn	19.96	28.94	3.45	16.4
Average	1240		16.66	31.25	3.20	17.5

To illustrate the general conformation of the cows in this group a picture of the Shorthorn cow Dido is given. The engraving was made from a photograph taken before the experiment began, and is an excellent likeness of the cow. She is large and blocky in outline, being level from base of horns to setting on of tail, deep well rounded thigh coming well down to hock, brisket low and running well forward, neck short and heavy at the shoulders, broad across the shoulders, full crops, ribs well sprung and body deep in the middle. She is in every way a very fine animal. She ate 18.76 pounds of dry matter per day, required

32.36 pounds of dry matter for each pound of butter fat, making the cost of butter fat 18.2 cents. Fancy is smaller in frame but carries more flesh. She is level on upper and lower lines, making her deeper in the flank and chest than Dido. She is closely ribbed, ribs well sprung making her level across the back, crops full, very heavy shouldered, broad across the withers and remarkably broad between the elbows indicating enormous lung capacity. She required 32.47 pounds dry matter for a pound of butter fat, making the butter fat cost 18.1 cents per pound. Sully is less inclined to lay on flesh than either of the others. She has less breadth of withers, crops quite low, deep and low in the middle and heavy thigh. She required 28.94 pounds dry matter for a pound of butter fat, making it cost 16.4 cents per pound. The cost of butter fat from group I. was 17.5 cents per pound.

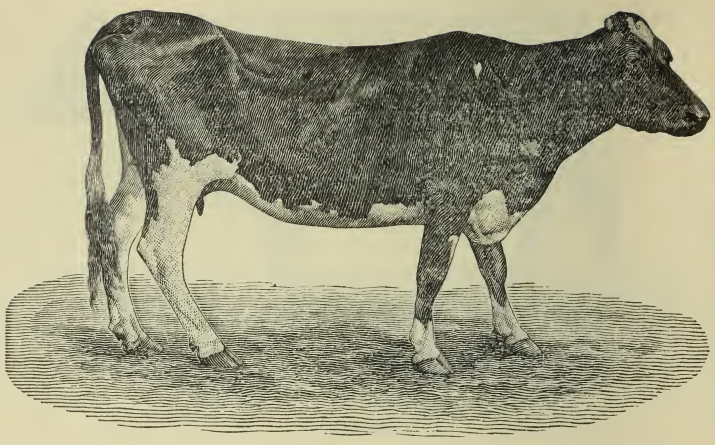


BECKLEY.

TABLE XVIII. Group II.—Cows Having Less Tendency to Lay on Flesh.

Cow.	Weight.	Breed.	Lbs. Dry Matter per day per 1000 lbs. live weight.....	Lbs. Dry Matter for 1lb. of butter fat.....	Lbs. butter Fat from 100 lbs of Dry Matter.	Cost of 1lb. of butter fat.....
						cents
Beckley	942	Gr. Jersey	25.15	25.08	3.98	14.3
Clara	909	" "	21.16	31.05	3.22	17.8
Reddie	1027	" Guernsey	21.02	24.44	4.09	13.8
Rossie	903	" Jersey	16.75	25.12	3.98	14.6
Average	945		21.02	26.42	3.82	15.1

This group would ordinarily be classed as fair dairy cows, but upon close inspection they show a well defined tendancy to growing flesh. Their hips (hooks), chines and withers are not as sharp as is the case with those in the two groups following. Their necks are rather short and a trifle heavy, thighs and crops too full. Rossie, a first-cross Jersey, carries the most flesh. Beckley, a high grade Jersey, follows next, both are more than ordinarily deep in body; Reddy and Clara are not as deep, and show less tendency to lay on flesh. The cows in Group II. consumed on an average 20.37 pounds dry matter per day, and required 26.42 pounds of dry matter for a pound of butter fat, costing 15.1 cents per pound.

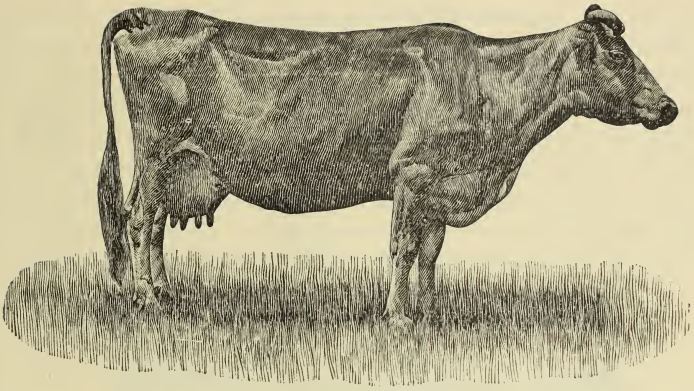


BETTIE.

TABLE XIX. Group III.—Cows Spare and Angular in Form, but Lacking Depth.

Cow	Weight	Breed	Lbs. dry matter per day per 1000 lbs. live weight	Lbs. of dry matter for 1 lb of butter fat	Lbs. of butter fat from 100 lbs. of dry matter	Cost of 1 lb. of butter fat
Jennie	1020	Gr. Holstein	22.09	28.58	3.49	16.6
Bettie	802	Guernsey	23.33	24.30	4.12	13.8
Olive	805	Gr. Guernsey	23.59	23.75	4.21	13.4
Average	875		23.00	25.54	3.94	14.6

The cows in this group are spare and angular, but lack in depth through the flank and middle. This is especially the case with Jennie, that has a restless, roving disposition always seeming to look for something better, while Olive and Bettie are more contented. Bettie is a fair representative of the cows in Group III.; they are not inferior dairy cows, their record for the year 1893 was 944 pounds of butter. They are the lightest feeders in the herd and require 25.54 pounds dry matter for a pound of fat, the butter fat costing 14.6 cents.



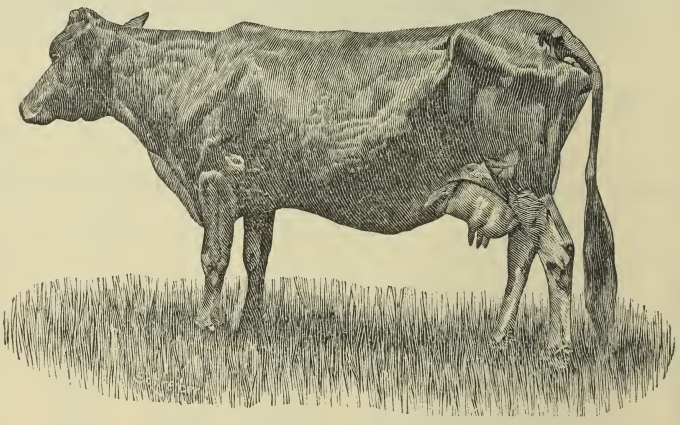
HOUSTON.

TABLE XX. Group IV.—Cows Spare and Angular with Deep Bodies.

Name of cows	Breed	Lbs. dry matter per day per 1000 lbs. live weights	Lbs. dry matter per 1 lb butter fat	Lbs. of butter fat from 100 lbs. of dry matter	Cost of 1 lb. of butter fat
					cents
Annie	Jersey	25.80	21.68	4.61	12.8
Bess	Holstein	22.04	21.29	4.69	12.3
Dora	Jersey	22.33	18.44	5.42	11.1
Gertie	Gr.- "	23.20	21.53	4.64	12.3
Houston	JerseyGuernsey	28.24	20.16	4.96	10.8
Patsy	Gr.-Jersey	22.20	22.27	4.49	12.6
Pride	Jersey	24.82	21.18	4.72	12.6
Rose	Shorthorn	17.87	21.37	4.67	12.9
Roxy	Gr.-Jersey	23.52	21.91	4.56	12.4
Sweet Briar	Guernsey	25.65	23.06	4.33	12.8
Topsy	Holstein	20.91	20.04	4.99	12.0
Tricksey	Guernsey	26.46	20.88	4.78	11.4
Average		23.58	21.15	4.73	12.1

The cows in group IV. embrace all in the herd not in the preceding groups except the heifer Nora, that is not classified for the reason that she made some growth during the year. It requires feed to make growth, consequently she is an exception to the conditions common to the other members of the herd. To give a better idea of the conformation of the cows in these groups, than can be done by words alone, the illustrations are given. Houston, a cross-bred Jersey-Guernsey consumed more feed per day and produced butter fat at less cost than any other cow in this trial. It is there-

fore proper that she should be selected as one of the representatives of the type of cow that gives best return for food consumed. The illustration is from a photograph taken after the close of the experiment. She is, and has been, in good health all the time she has been in the herd. Her appetite is clearly shown by the fact that she ate 28.24 pounds of dry matter daily during the test; the standard being 24 pounds. That she made good use of it—possibly the best that could be—is evident from the cost of butter fat, 10.8 cents per



DORA.

pound. Dora follows next in productive capacity, making a pound of butter fat for 11.1 cents, and returning a pound of fat for every 18.44 pounds of dry matter consumed. The average number of pounds of dry matter eaten per day by the group is 23.58; average pounds of dry matter for a pound of fat 21.15; cost of a pound of fat 12 1 cents. The cows in group IV deviating the most from the type as represented by Houston and Dora, are Rose, Annie and Sweet Brier, deviation being in the order named. In examining the cost of butter fat in this group it will be seen that Rose produces it for 12.9 cents and Annie and Sweet Brier each for 12.8 cents per pound.

TABLE XXI.—Averages of the Four Groups.

Group	Dry matter eaten per day...	Dry matter per 1000 lbs. of live weight	Dry matter per lb. of butter fat	Butter fat for 100 lbs. of dry matter	Cost of a lb. of butter fat.....
I	20.81	16.66	31.25	3.20	17.5
II	20.37	21.02	26.42	3.78	15.1
III	19.95	23.00	25.54	3.91	14.6
IV	21.86	23.58	21.15	4.72	12.1

It appears from the foregoing table that group I.. the heavy beefy cows, consumed 20.81 pounds of dry matter per day and required 31.25 pounds dry matter for a pound of butter fat; that group II., the cows having an angular form, but a tendency to lay on flesh, consumed 20.37 pounds dry matter per day and required less to make a pound of butter fat than the first group; while group III., the spare cows lacking somewhat in depth of body, consumed 19.95 lbs. food daily, and required less dry matter for a pound of fat than groups I. and II., and that group IV., the spare, deep bodied cows, consumed the most feed per day and made the best use of it. The cost of butter fat as indicated in the last column, seems to depend more upon the type of cow than the breed, there being less variation in cost of production between cows of a certain type than between cows of the same breed. The cost of one hundred pounds of dry matter was 57 cents; estimating the price of a pound of butter fat at 25 cents the cows in group I. returned a net profit of 23 cents for each hundred pounds of dry matter consumed; group II., 37 cents; group III., 41 cents and group IV., 61 cents. Referring to table XXI., it will be seen that the first group consumed, on an average, 20.81 pounds dry matter per day, returning 4.7 cents profit; the cows in group II, ate 20.37 pounds dry matter and gave 7.5 cents profit; group III. ate 19.95 pounds each and returned 8.1 cents, while group IV. ate 21.86 pounds each per day at a profit of 13.3 cents, or nearly three times as great a net profit as the blocky cows in group I.

SUMMARY.

The record of the dairy herd for the year 1893 seems to warrant the following conclusions:

First. The average annual cost of keeping a dairy cow is thirty-eight dollars.

Second. A herd of cows bred on dairy lines, well fed and carefully handled, will produce on an average six thousand four hundred pounds of milk per year at a cost of sixty-two cents per hundred pounds and twelve and a half cents a pound for butter fat.

Third. A herd of good dairy cows well fed and carefully handled will produce on an average three hundred pounds of butter fat each per year, which is equivalent to three hundred and sixty-five pounds of butter per cow.

Fourth. The average cost of a pound of butter will be ten and a half cents.

Fifth. Taking the entire herd the average cost of a pound of butter fat during the winter months is thirteen and nine-tenths cents.

Sixth. The productive capacity of a cow depends more upon type and conformation than upon size or breed. Those of the beef type produced butter fat at a cost of seventeen and a half cents per pound; those carrying a medium amount of flesh produced butter fat at a cost of fifteen and one-tenth cents per pound; the spare cows lacking in depth of body produced butter fat at a cost of fourteen and six tenths cents per pound and the spare cows having deep bodies produced butter fat at a cost of twelve and one tenth cents per pound.

COMPARING PRAIRIE HAY WITH TIMOTHY HAY.

T. L. HÆCKER.

In a state like Minnesota where so large a portion is composed of open prairie still covered with the virgin grasses, the question of their food value is one of no little moment, especially in all that section north and west of the Twin Cities. For that section the, almost, universal roughage-feed for horses, cattle and sheep is the upland prairie hay.

The term employed to designate this hay is rather ambiguous; prairie hay consists of many varieties of grasses, depending, to a certain extent, upon composition of soil and degree of moisture. But if practical investigation into the value of the native grasses, for the production of milk and growing of young stock, be deferred until these grasses are all divided and classified and the relative proportion of each contained in a given quantity of hay, is computed, there will be little use for the facts after they are obtained. For feeding purposes, prairie grasses can be divided into three classes, the upland, the dry bottom land and the swale or marsh grasses. Of these the upland prairie is the most common and for this reason it was selected for an experiment in milk production in comparison with timothy hay.

Character of Hay Fed.—The prairie hay secured was fine in blade, of good quality, apparently early cut and not exposed to rain before stacking. It was almost free from swale grass and tall blue joint. The timothy hay was medium fine, rather short, cut early and properly cured, had a fine flavor, good color and was first grade in every respect.

The intention was to carry this experiment from the first of February to the first of May, covering the period, March and April, when it is most difficult to get satisfactory results in a feeding experiment with dairy cows. But it was not until about the middle of February that the cows adjusted them-

selves to the rations selected. There was no difficulty experienced in feeding prairie hay but it required careful training to induce all of them to eat the timothy clean.

The mixed grain ration consisted of 98 pounds bran, 44 pounds ground barley, 44 pounds ground corn and 26 pounds linseed meal.

Sixteen cows were selected for the experiment and were divided into four groups, and the time into four periods. The daily feeding program was as follows:

Lot 1—Periods I and III, Grain 14 lbs., Prairie hay 14 lbs.
Lot 1—Periods II and IV, Grain 14 lbs., Timothy hay 14 lbs.
Lot 2—Periods I and III, Grain 14 lbs., Timothy hay 14 lbs.
Lot 2—Periods II and IV, Grain 14 lbs, Prairie hay 14 lbs.
Lot 3—Periods I and III, Grain 12 lbs., Ensilage 10 lbs., Prairie hay 11 lbs.
Lot 3—Periods II and IV, Grain 12 lbs., Ensilage 10 lbs., Timothy hay 11 lbs.
Lot 4—Periods I and III, Grain 12 lbs., Ensilage 10 lbs., Timothy hay 11 lbs.
Lot 4—Periods II and IV, Grain 12 lbs., Ensilage 10 lbs., Prairie hay 11 lbs.

CONDUCT OF THE EXPERIMENT.

The feeding preliminary to the experiment, began the 22nd day of January, continuing to the 12th of February, when the experiment proper commenced and it was closed the evening of the 29th of April. It was divided into four periods of fourteen days each with seven days intervening between periods for preliminary feeding. During the first and third periods the cows in Lot 1 were fed on grain and prairie hay; Lot 2, on grain and timothy hay; Lot 3, grain, ensilage and prairie hay and Lot 4, grain, ensilage and timothy hay. During the second and fourth periods, the cows in Lot 1, were fed grain and timothy hay; Lot 2, grain and prairie hay; Lot 3, grain, ensilage and timothy hay and Lot 4, grain, ensilage and prairie hay. The cows were fed twice and watered once a day, and weighed every Monday morning after feeding and before watering. The feed was weighed each day and in a few instances when feed was left it was weighed back, giving due credit to the cow leaving it.

In the preliminary feeding between the first and second periods, Daisy, in Lot 1 went off her feed and did not recover in time to enter the trial in the second period. She was therefore dropped from the experiment. Betty also at one

time refused to eat the full amount of timothy hay, but it was so near the close of the second period that no perceptible change took place in her yield of milk and butter fat. During the third and fourth periods she was in excellent condition and gained, both in milk and in butter fat, though during the last week ot the experiment she refused to eat all the timothy. Fancy was offered the hay left by Bettie but she refused to take it. In the third period, when changing from prairie to timothy, Clara in Lot 2, failed to eat the required amount of timothy and, showing abnormal loss in both milk and fat, was taken out of the experiment. Beckley, in Lot 3, ate all the feed given but showed by her appearance and performance that she was not in normal condition, which subsequent developements confirmed. During the first period, Jenny in Lot 4, refused to eat a full ration of timothy, and throughout the experiment, showed that the ration was a trifle too large when on timothy hay. She seemed to like the wild hay much better, increasing both in yield of milk and fat when on prairie hay. Because of the break in the first period and other peculiarities noted, she was taken out of the trial, which left three cows in each lot. All of them were fed to their full capacity for so long a period except Sweet Brier and possibly, Topsy; the former would have taken a few pounds more and the latter might have taken half as much.

Every milking of each cow was weighed and tested for per cent fat, as has been our invariable practice since the establishment of the dairy herd in the autumn of 1891.

The daily grain ration was as follows:

Lots 1 and 2	Lots 3 and 4
Bran 6.17 lbs.	Bran 5.29 lbs.
Barley 3.08 lbs.	Barley 2.64 lbs.
Corn 3.08 lbs.	Corn 2.64 lbs.
Linseed Meal 1.65 lbs.	Linseed Meal 1.41 lbs.

Samples of Grain, Hay and Ensilage.—Samples of the grain were taken in Mason pint jars and sealed. The samples of ensilage were taken by the chemist, and both prairie and

timothy hay were sampled every day and a composite sample of each was analyzed.

All the work in connection with the experiment was done by students attending the School of Agriculture. Messrs. Walter Field and A. J. Glover had charge of the feeding; W. C. Currie, R. W. Clark and James McGrath did the milking; Archie L. Haecker tested the milk with the Babcock test and Ernest W. Major kept the record and computed the yield of milk and fat. The milk was weighed and sampled by the milkers. All the work was done with that zeal and earnest fidelity which can only be secured through those who take a deep interest in obtaining accurate results in an experiment of this kind.

Since the ration fed to Lot 1 and Lot 2 differed from that fed to Lot 3 and Lot 4, the results obtained from the first two groups will be considered separate from that of the last two.

TABLE XXII.—Cows, Weights, Date of Calving and Date of Service.

Name	Age	Breed	Wt.	Date of calving	Served
Bettie	9	Guernsey	846	Aug., 1893	Dec. 30, 1893
Daisy	2½	Grade Guernsey	.....	.....	April 10, 1894
Gertie	5	Grade Jersey	874	Sept. 26, 1893	Nov. 15, 1894
Fancy	8	Polled Angus	1246	Mar., 1893	.....
Houston	10	Jersey-Guernsey	867	Nov. 5, 1893	Jany. 9, 1894
Roxy	9	Gr. Jersey	936	Aug. 10, 1893	Nov. 10, 1893
Clara	8	" "	.....	May 27, 1893	.....
Sully	10	" Shorthorn	1173	July 5, 1893	Nov. 19, 1893
Beckley	9	" Jersey	.....	July 10, 1893	Nov. 13, 1893
Mollie	2½	" Shorthorn	950	.....	Dec. 27, 1893
Pride	11	Jersey	748	May 2, 1893	Nov. 30, 1893
Nora	4	" -Guernsey	827	Aug. 15, 1893	Nov. 26, 1893
Jenny	6	Gr. Holstien	.....	Nov. 27, 1893	Jan. 17, 1894
Sweet Brier	10	Guernsey	1025	Oct. 28, 1893	Jan. 30, 1894
Rossie	6	Gr. Jersey	916	May 15, 1893	Dec. 15, 1893
Topsy	8	" Holstien	1030	Nov. 9, 1893	Dec. 28, 1893

The weight of the cows is the average of the weight of each on the 5th and 12th of February at the beginning of the experiment.

The composition of the bran, barley, corn, ensilage, timothy and prairie hay and percentage digestible of bran, barley and corn was obtained by analyses and experiments made by Prof. Harry Snyder. The co-efficients employed in calculating the amount digestible in timothy and prairie hay were taken from the Massachusetts State Experiment

TABLE XXIII.—Composition of Feed Stuffs Used.

	Percentage composition.						Lbs. digestible.			
	Water	Ash	Protein	Carbo hydrates	Fiber	Fat	Protien	Carbo hydrates	Fiber	Fat
Bran	10.40	5.95	15.38	52.87	10.25	5.05	11.55	34.89	3.38	3.63
Barley	11.78	.....	11.57	65.63	6.00	2.70	9.42	56.82	2.92	1.89
Corn	11.72	.....	11.25	69.40	2.28	3.88	10.11	65.16	1.11	3.01
Linseed meal	9.20	5.70	32.90	35.40	8.90	7.90	27.00	32.00	2.00	7.10
Timothy hay	12.32	4.58	6.53	44.57	28.83	3.17	3.17	28.97	16.14	1.81
Prairie hay	10.85	6.28	5.91	47.81	26.32	2.83	2.36	27.73	13.16	1.42
Ensilage	72.00	1.41	2.42	17.19	6.00	1,06	1.10	13.00	2.00	.70

Station Annual Report for 1893; using the co-efficient from "hay of mixed grasses low in nitrogen," for the prairie hay. For ensilage and linseed meal those used in the Annual Report of the Wisconsin Experiment Station for 1892 were employed.

FEED CONSUMED AND MILK AND BUTTER FAT PRODUCED BY LOTS 1 and 2.

The following tables give the amount of grain and hay eaten and pounds of milk and butter fat produced by each cow in Lots 1 and 2 during the four periods:

TABLE XXIV. Lot 1.

	Period I. Feb. 12—25.				Period II. Mch. 5—18.			
	Grain	Prairie hay	Milk	Fat	Grain	Timothy	Milk	Fat
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Bettie	196	194	117.8	7.52	196	140	124.0	7.72
Fancy	196	196	129.4	6.50	196	196	138.2	5.89
Gertie	196	195	223.6	11.67	196	196	213.8	10.33
Total	588	585	470.8	25.69	588	532	476.0	23.94

	Period III. Mch. 26—April 8.				Period IV. April 16—29.			
	Grain	Prairie hay	Milk	Fat	Grain	Timothy	Milk	Fat
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Bettie	196	196	129.9	8.61	196	181.5	133.5	9.11
Fancy	196	196	137.1	6.02	196	196	120.9	5.53
Gertie	196	196	214.1	10.70	196	182.5	207.8	10.64
Total	588	588	481.1	25.33	588	560	462.2	25.28

It will be observed that Bettie gained in Period II. 6.2 pounds of milk and .2 of a pound fat over that given by her during Period I. During Period III. she gained 5.9 pounds of milk and .89 of a pound of fat over Period II, and during Period IV. 3.6 pounds of milk and .5 of a pound of fat over Period III. In Period II. Fancy gained, while on timothy, 8.8 pounds of milk and lost .61 of a pound of fat as compared with Period I., while in Period III. on prairie hay she lost 1.1 pounds of milk and gained .13 of a pound of fat, and in Period IV, on timothy she lost 16.2 pounds of milk and .49 of a pound of fat. Gertie lost in yield of fat during both periods when fed on timothy, and regained a trifle when on praire hay in Period III.

TABLE XXV. Lot 2.

	Period I. Feb. 12—25.				Period II. Mch. 15—18.			
	Grain	Timothy	Milk	Fat	Grain	Prairie hay	Milk	Fat
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Houston	196	193	281.0	15.15	196	196	312.6	14.66
Roxy	196	196	213.9	10.38	196	196	221.4	11.04
Sully	196	196	238.2	11.25	196	996	257.8	11.06
	588	585	733.1	36.78	588	588	791.8	36.76

	Period III. Mch. 26—Apr. 8.				Period. IV. Apr. 16—29.			
	Grain	Timothy	Milk	Fat	Grain	Prairie hay	Milk	Fat
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Houston	196	196	299.3	14.83	196	196	295 4	15.02
Roxy	196	196	209.9	10.86	196	196	209.3	11.51
Sully	196	196	242.3	11.16	196	196	259.7	12.05
Total	588	588	764.4	36.85	538	588	764.4	38.58

In the above table is given the amount of grain and hay eaten and milk and fat produced by each cow during the four periods, and also the total pounds of feed eaten and milk and butter fat produced by Lot 2 during the four periods. During the first three periods there was scarcely any variation in the total amount of butter fat produced by the three cows. During the fourth period while the cows received prairie hay they gained 1.76 pounds fat.

With one exception Lot 2 ate all the feed given during the four periods, Houston on a single occasion refused to eat all the hay. The hay left was weighed and deducted, making the amount of hay consumed 193 pounds, being 3 pounds less than that eaten by the other cows in the group.

Comparing the yields of milk and butter fat during the first period with that of the fourth it will be seen that the cows gained both in yield of milk and of fat during the trial, showing that the cows were in excellent working condition and responded well to the care bestowed in feeding and milking.

SUMMARY OF RESULTS WITH LOTS 1 AND 2.

By adding the total amount of milk yielded by Lot 1 during Periods I. and III. and Lot 2 during Periods II. and IV. we find the number of pounds of milk and butter fat yielded when feeding prairie hay. The total amount of milk and butter fat produced by Lot 1. during Periods II. and IV., and by Lot 2 during Periods I. and III. gives the number of pounds of milk and fat yielded when feeding on timothy hay.

The following table gives the total quantity of grain, timothy hay and prairie hay eaten and milk and butter fat produced by Lots 1 and 2 during each of the four periods:

TABLE XXVI. Comparing Prairie Hay With Timothy for Milk and Butter Fat.

Timothy Hay.						Prairie Hay.					
		Grain	Timothy hay	Milk	Fat			Grain	Prairie hay	Milk	Fat
Lot	Period					Lot	Period				
1	II	588	532	476.0	23.94	1	I	588	585	470.8	25.69
1	IV	588	560	462.2	25.28	1	III	588	588	481.1	25.33
2	I	588	585	733.1	36.78	2	II	588	588	791.8	36.76
2	III	588	588	751.5	36.85	2	IV	588	588	764.4	38.58
		2352	2265	2422.8	122.85			2352	2349	2508.1	126.36

During the four periods the cows when fed on prairie hay consumed as much grain as they did when fed on timothy. Eliminating this common factor we have the following result:

2,265 pounds of *timothy hay* with grain produced 2,422.8 pounds of milk containing 122.85 pounds of fat.

2,349 pounds of *prairie hay* with a similar amount of grain produced 2,508.1 pounds of milk containing 126.36 pounds of fat.

During the periods when prairie hay was fed, the cows in Lots 1 and 2 produced 85.3 pounds more milk and 3.51 pounds more butter fat than they did during the periods when timothy hay was fed.

Applying the standard of values for the two kinds of hay adopted on page 39 of this report, being $5.60 per ton for timothy and $3.20 for prairie hay, it is found that the cost of the daily ration fed to Lot 1, during Periods I and III and to Lot 2, during Periods II and IV, when fed on grain and prairie hay, was 12.1 cents, and the cost of the daily ration fed to Lot 1 during Periods II and IV and to Lot 2 during Periods I and III, when fed on timothy hay, was 13.8 cents. During the 28 days when the cows were fed on grain and timothy hay they consumed $23.18 worth of feed and produced 2,422.8 pounds of milk and 122.85 pounds of butter fat; the milk costing 95 cents per hundred pounds and the butter fat 18.8 cents per pound.

During the 28 days when fed on grain and prairie hay, they consumed $20.33 worth of feed and produced 2,508.1 pounds of milk and 126.36 pounds of butter fat; the milk costing 81 cents per hundred pounds and the butter fat 16 cents per pound, being a difference of 14 cents per hundred pounds of milk and 2.8 cents per pound of butter fat, in favor of prairie hay.

FEED CONSUMED AND MILK AND BUTTER FAT PRODUCED BY LOTS 3 AND 4.

Twelve cows were in the experiment proper. Six, as we have seen, were fed a fundamental grain ration of 14 pounds each daily with 14 pounds of timothy or prairie hay, three receiving prairie hay and three timothy in alternation during the four periods. The other six were divided into two groups designated as Lot 3 and Lot 4, and received a fundamental ration of 12 lbs. of grain and ten pounds of ensilage with

11 lbs. of timothy or prairie hay, the hay being fed in alternation during the four periods the same as with Lots 1 and 2, mentioned above. While there is a slight variation in the amount of milk and fat produced by each cow during the four periods, the amount produced by each group shows remarkable uniformity and persistency in yield. Pride during the first period in February gave 210.7 lbs. of milk and 11.44 lbs. of butter fat and during the fourth period she gave 215.1 lbs. milk and 11.80 lbs. of fat showing that she gained both in flow of milk and in yield of fat during the experiment. By examining the records of the other cows in the group it will be seen that there was a gradual increase in the yield of butter fat as the experiment progressed. During the first period the three cows yielded 26.67 lbs. of fat while during the fourth period they produced 29.48 lbs. a gain of 2.81 lbs. fat. During Periods I and III when the cows were fed on grain, ensilage and prairie hay the yield of milk was 1,081.9 lbs. and butter fat 55.53 lbs; and during Periods II and IV when timothy was substituted they gave 1,123.1 lbs. of milk and 57.54 lbs. butter fat, being an excess of 41.2 lbs. of milk and 2.01 lbs. of fat when timothy hay was fed.

Results in feeding experiments with dairy cows are at best a mystery. There are so many things, other than feed, that will cause a change in the flow of milk and its fat content that it is very difficult to account, always, for such changes. With all the close attention and care that was bestowed upon the cows during the trial we failed to find the cause of the steady increase in yield of fat by Nora. Neither can it be explained why Molly should gain 23 pounds in milk in the second period when on timothy and not gain, but give less, in the fourth period when on timothy. In the second period she gave 180.9 pounds of milk, containing 7.57 pounds of fat, while in the fourth, 148.2 pounds contained 8.08 pounds of fat, a marked increase in the per cent of fat without any apparent cause.

The following tables give the number of pounds of grain, ensilage and hay eaten and the amount of milk and butter fat produced by each cow in Lots 3 and 4 during the four periods:

TABLE XXVII. Lot 3.

	Period I. Feby. 12—25.					Period II. March 5—18.				
	Grain	Ensilage	Prairie hay	Milk	Fat	Grain	Ensilage	Timothy	Milk	Fat
	lbs.	lbs.	lbs.			lbs.	lbs.	lbs.		
Mollie	168	140	152	157.6	7.39	168	140	154	180.9	7.57
Nora	165	140	148	150 1	7.84	168	140	154	166.3	8.30
Pride	168	140	154	210.7	11.44	168	140	154	246.1	12.19
Total	501	420	454	518.4	26.67	504	420	462	593.3	28.06

	Period III. Mch. 26—Apr. 8.					Period IV. Apr. 16—29.				
	Grain	Ensilage	Prairie hay	Milk	Fat	Grain	Ensilage	Timothy	Milk	Fat
	lbs.	lbs.	lbs.			lbs.	lbs.	lbs.		
Mollie	168	140	154	152.7	7.23	168	140	154	148.2	8.08
Nora	168	140	154	169.9	9.22	168	140	154	166 5	9.60
Pride	168	140	154	240.9	12.41	168	140	154	215.1	11.80
Total	504	420	462	563.5	28.86	504	420	462	529.8	29.48

TABLE XXVIII. LOT 4.

	Period I. Feb. 12—25.					Period II. Mch. 5—18.				
	Grain	Ensilage	Timothy	Milk	Fat	Grain	Ensilage	Prairie hay	Milk	Fat
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbr.	lbs.	lbs.	lbs.
Rossie	168	140	149	213.9	9.20	168	140	154	226.1	9.10
Sweet Briar	168	140	154	194.6	10.76	168	140	154	197.6	10.00
Topsy	168	140	151	306.5	12.82	168	140	154	325.9	13.02
Total	504	420	454	715.0	32.78	504	420	462	749.6	32.12

	Period III. Mch. 26—Apr. 8.					Period. IV. Apr. 16—29.				
	Grain	Ensilage	Timothy	Milk	Fat	Grain	Ensilage	Prairie hay	Milk	Fat
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Rossie	168	140	154	232-5	9.61	168	140	154	245.8	10.14
Sweet Briar	168	140	154	197.0	10.06	168	140	154	218.8	11.06
Topsy	168	140	154	279.7	11.32	168	140	154	290.2	11.89
Total	504	420	262	709.2	30.99	504	420	462	754.8	33.09

During period I Rossie in Lot 4 refused 5 lbs. of timothy, and Topsy refused 3 lbs of timothy which were weighed back. During the other periods all the grain, ensilage and hay offered was eaten. In yield of milk Rossie gained gradually during the experiment giving 213.9 lbs. in the first period and 245.8 in the fourth. In fat she lost .1 lb. in the second, gained .51 of a pound in the third and .53 of a pound in the fourth. Sweet Brier gave almost exactly the same amount of milk during the first three periods and in the fourth, on prairie hay, gained 21.8 lbs. Her variation in yield of butter fat was slight; losing .76 of a pound in the second period and gaining 1 lb. in the fourth, both on prairie hay. Topsy gained in milk and fat in the second while on prairie hay, lost in milk and fat, while in the third on timothy and gained in both milk and fat during the fourth on prairie hay. Comparing the yield of milk and fat during the first period with that of the fourth it will be seen that the lot gained both in milk and fat during the experiment giving 39.8 lbs. more milk and .31 of a pound more fat the last period than the first.

SUMMARY OF RESULTS WITH LOTS 3 AND 4.

Adding the yield of milk and butter fat of Lot 3 during Periods I and III with that of Lot 4 during Periods II and IV we find the number of pounds of milk and butter fat produced while fed on prairie hay. And adding the total amount of milk and fat produced by Lot 3 during Periods II. and IV., and by Lot 4 during Periods I. and III. gives the amount of milk and butter fat yielded by the cows when fed on timothy hay.

The following table gives the amount of grain, ensilage, timothy and prairie hay eaten and milk and butter fat produced by Lots 3 and 4, during each of the four periods:

TABLE XXIX--Comparing Prairie Hay with Timothy for Milk and Butter Fat.

Prairie Hay.

		Grain	Ensilage	Hay	Milk	Fat
Lot 3	Period I	501	420	454	518.4	26.67
" 3	" III	504	420	462	563.5	28.86
" 4	" II	504	420	462	749.6	32.12
" 4	" IV	504	420	462	754.8	33.09
		2013	1680	1840	2586.3	120.74

Timothy Hay.

		Grain	Ensilage	Hay	Milk	Fat
Lot 3	Period II	504	420	462	593.3	28.06
" 3	" IV	504	420	462	529.8	29.48
" 4	" I	504	420	454	715.0	32,78
" 4	" III	504	420	462	709.2	30.99
		2016	1680	1840	2547.3	121.31

The amount of grain, ensilage and hay eaten by the cows in Lots 3 and 4 was practically the same We have therefore the following result:

The cows fed on *prairie hay*, grain and ensilage produced during the experiment 2,586.3 lbs. of milk containing 120.74 lbs. of butter fat.

The cows fed on *timothy hay*, grain and ensilage produced 2,547.3 lbs. of milk containing 121.31 lbs. of butter fat. The difference being 39 lbs. of milk in favor of *prairie hay* and 5.7 of a pound of butter fat in favor of *timothy*.

During the periods when prairie hay was fed the cows in Lots 3 and 4 produced 39 lbs. more milk and .57 of a pound less butter fat than they did during the periods when timothy hay was fed.

Applying the standard of values for the two kinds of hay used in the first part of this report, being $5.60 per ton for timothy and $3.20 for prairie hay, the cost of the daily ration fed to Lot 3 during Periods I. and III. and to Lot 4 during Periods II. and IV. when fed on grain, ensilage and prairie hay was 11.1 cents. And the cost of the daily ration fed to Lot 3 during Periods II. and IV. and to Lot 4 during Periods I. and III. when fed on timothy hay was 12.4 cents.

During the 28 days when the cows were fed on grain, ensilage and prairie hay they consumed $18.64 worth of feed and produced 2,586.3 lbs. of milk and 120.74 lbs. of butter fat; the milk costing 72 cents per hundrek pounds and the butter fat 15.4 cent per pound.

During the periods when they were fed on grain, ensilage and timothy hay they consumed $20.83 worth of feed and produced 2,547.3 lbs. of milk and 121.31 lbs. of butter fat; the milk costing 81.7 cents per hundred lbs. and the butter fat 17.1 cents per pound, being a difference of 9.7 cents per hundred pounds of milk and 1.7 cents per pound of butter fat in favor of the ration when prairie hay was fed.

Taking the results of the four lots of cows we find that when timothy was fed the average cost of a hundred pounds of milk was 88.3 cents and the average cost of a pound of butter fat was 17.9 cents, and during the periods when prairie hay was fed the average cost of a hundred pounds of milk was 76.5 cents, and the cost of pound of butter fat was 15.7 cents, being 11.8 cents less per hundred pounds of milk and 2.2 cents less per pound of butter fat when prairie hay was fed.

GENERAL SUMMARY.

As the results of two experiments conducted with twelve cows comparing the nutritive value of timothy and prairie hay for milk and butter fat production we have the following testimony:

First: As between early cut and well cured timothy hay and fine well cured upland prairie hay, cows prefered the prairie hay.

Second: Prairie hay was at least equal to timothy for the production of milk and butter fat.

Third: At the present price of the two kinds of hay, milk was produced at thirteen per cent. less cost, and butter fat at twelve per cent. less cost when prairie hay was fed.

Fourth: With dairy cows fresh in milk in the fall or early winter, comfortably housed, well and regularly fed and milked, there will be little if any shrinkage in the flow of milk and yield of butter fat during the winter months.

DIGESTIBLE NUTRIENTS IN THE RATIONS.

In planning this experiment no note was taken as to the amount of the different nutrients contained in the rations selected. The kind and quantity of feed stuff was made up from a dairyman's standpoint and the amount of protein and carbohydrates and the nutritive ratio of the four rations used was not calculated until several months after the experiments closed. The remarkable results obtained in this experiment in regard to the uniform and persistent flow of milk and yield of butter fat during so long a trial, makes the nutritive ratio of the rations and the amount of protein, carbohydrates and fat they contained a matter of considerable interest.

The experiment commenced on the 12th of February and closed with the 29th day of April, being a period of 77 days. During the first period of the experiment commencing the 12th and closing the 25th of February the twelve cows gave 2,8628.2 lbs. of milk and 139.74 lbs. butter fat and during the last period commencing the 16th of April and ending with the 29th of April they gave 2,922.6 lbs. of milk and 142.37 lbs. of butter fat being 60.4 lbs. more of milk and 2.63 lbs. more butter fat than they gave the first period.

In the following table is given the the dry organic matter and the digestable nutrients in the rations fed to lots 1 and 2; to lot 1 during periods I. and III. and to lot 2 during periods II. and IV.

TABLE XXX.—Digestible Nutrients in Ration when Grain and Prairie Hay were Fed.

Kind of Feed	Lbs of Feed	Dry Organic Matter	DIGESTIBLE			Digestible Nutrients Lbs	Nutritive ratio
			Protein	Carbohydrates	Fat		
Bran	6.17	5.53	.71	2.36	.22	3.29	
Barley	3.08	2.72	.29	1 84	.06	2.19	
Corn	3 08	2.72	.31	2.04	.09	2.44	
Linseed Meal	1.65	1.56	.45	.52	.12	1.09	
Prairie Hay	14.00	12.48	.33	5.72	.20	6.25	
Total	27.98	24.95	2.09	12.48	.69	15.26	1:6.7

The six cows in lots 1 and 2, during the periods when prairie hay was fed took 24.95 lbs. of dry matter containing

2.09 lbs. protein, 12.48 lbs. carbohydrates and .69 lbs. of fat making 15.26 lbs. digestible nutrients daily; during which periods they ate 2,563.68 lbs. of digestible dry matter. By referring to table XXVI. it will be seen that the cows in lot 1, periods I. and III. and lot 2, periods II. and IV. gave 2,508.1 lbs. of milk containing 126.36 lbs. of butter fat, which is equivalent to 97.83 lbs. of milk containing 4.92 lbs. of butter fat for every 100 lbs. of digestible nutrients.

In the following table is given the dry organic matter and the digestible nutrients in the rations fed to lots 1 and 2; to lot 1 during periods II. and IV. and to lot 2 during periods I. and III.

TABLE XXXI—Digestible Nutrients in Ration when Grain and Timothy Hay were Fed.

Kind of Feed	Lbs of Feed	Dry Organic Matter	DIGESTIBLE			Digestible Nutrients	Nutritive ratio
			Protein	Carbohydrates	Fat		
Bran	6.17	5.53	.71	2.36	.22	3.29	
Barley	3.08	2.72	.29	1.84	.06	2.19	
Corn	3.08	2 72	.31	2.04	.09	2.44	
Linseed Meal	1.65	1.50	.45	.52	.12	1.09	
Timothy Hay	14.00	12.28	.44	6.32	.25	7.01	
		24.75	2.20	13 08	.74	16.02	1:6.7

The six cows in lots 1 and 2 while on timothy hay ate 24.75 lbs. dry matter per day during the four periods containing 2.2 lb. protein, 13.08 lbs. carbohydrates, .74 of pound of fat. The total digestible nutrients taken by each cow per day was 16.02 lbs. Deducting the amount refused makes a total for the six cows during the two periods of 2,649.36 lbs. By referring to table XXVI. it will be seen that the cows in lots 1 and 2 while on timothy hay yielded 2,422.8 lbs. of milk and 122.85 lbs. of butter fat, which is equivalent to 91.50 lbs. of milk containing 4.63 lbs. of butter fat for every 100 lbs. digestible nutrients.

Summing the results of the two lots during the four periods we have the following:

	Milk produced per 100 lbs. of digestible matter	Fat produced per 100 lbs. of digestible matter
	Lbs.	Lbs.
With Grain and Prairie Hay	97.83	4.92
With Grain and Timothy Hay	91.50	4.63
In favor of Prairie Hay	6.33	.29
Per cent	6.9	6.2

Lots 3 and 4 were fed ensilage in addition to hay and grain. The results obtained by the cows in these lots are therefor considered seperately. The rations fed to lot 3 during periods I. and III. and to lot 4 during periods II. and IV. is given in the following table:

TABLE XXXII—Digestible Nutrients in Ration when Grain Ensilage and Prairie Hay were Fed.

Feed	Lbs Feed	Lbs Dry Matter	DIGESTIBLE			Total Digestible dry matter	Nutritive ratio
			Protein	Carbohydrates	Fat		
Bran	5.29	4.74	.61	2.02	.19	2.82	
Barley	2.64	2.33	.25	1.58	.05	1.88	
Corn	2.64	2.33	.27	1.75	.08	2.10	
Linseed Meal	1.41	1.28	.38	.45	.10	.93	
Prairie Hay	11.00	9.81	.26	4.50	.14	4.90	
Ensilage	10.00	2.80	.11	1.32	.07	1.50	
	32.98	23.29	1.88	11.62	.63	14.13	1:6.8

The six cows in lots 3 and 4 during the periods when prairie hay was fed received 23.29 lbs. of dry matter daily containing 1.88 lbs. protein, 11.62 lbs. carbohydrates and .63 of a pound of fat, making 14.13 lbs. digestible nutrients. During the four periods when on prairie hay they ate 2,373.-84 lbs. digestible dry matter, and produced 2,586.3 lbs. of milk containing 120.74 lbs. of butter fat which is equivalent to 108.95 lbs. of milk and 5.08 lbs. butter fat for every 100 lbs. digestible dry matter taken.

The ration fed to lots 3 and 4 during periods when timothy was fed, is given in the following table:

TABLE XXXIII.—Digestible Nutrients in Ration when Grain, Ensilage and Timothy Hay were Fed.

	Lbs Feed	Lbs Dry Matter	DIGESTIBLE			Total Digestible dry matter	Nutritive ratio
			Protein	Carbohydrates	Fat		
Bran	5.29	4.74	.61	2.02	.19	2.82	
Barley	2.64	2.33	.25	1.58	.05	1.88	
Corn	2.64	2.33	.27	1.75	.08	2.10	
Linseed Meal	1.41	1.28	.38	.45	.10	.93	
Timothy Hay	11.00	9.64	.35	4.96	.20	5.51	
Ensilage	10.00	2.80	.11	1.32	.07	1.50	
	32.98	23.12	1.97	12.08	.69	14.14	1:6.9

The six cows in lots 3 and 4 during the periods when timothy hay was fed received 23.12 lbs. of dry matter daily containing 1.97 lbs. protein, 12.08 lbs. of carbohydrates and .69 of a pound of fat making 14.74 pounds of digestible nutrients. During the periods when fed on timothy hay they ate 2,476.32 lbs. digestible nutrients and produced 2,547.3 lbs. of milk containing 121.31 lbs. of butter fat which is equivalent to 102.86 lbs. of milk containing 4.89 lbs. of butter fat for every 100 lbs. of digestible dry matter eaten.

Comparing the results obtained when the two groups were fed on prairie hay with that when fed on timothy hay we have the following:

	Milk produced per 100 lbs. digestible dry matter	Butter fat produced per 100 lbs. digestible dry matter
	Lbs	Lbs
With grain, ensilage and prairie hay	108.95	5,08
With grain, ensilage and timothy hay	102.86	4.89
In favor of Prairie Hay	6.09	.19
Per cent	5.9	3.9

While the results obtained with the two different groups of cows are not comparable for the reason that the last two groups received ensilage in addition to grain and hay, yet it is interesting to note that the cows receiving ensilage produced 11.24 pounds more milk and .21 of a pound more fat from 100 pounds digestible dry matter than was given by the cows in lots one and two, fed on grain and hay; also that the cows receiving ensilage had a ration having a nutrition ratio of 1:6.9, while groups one and two were fed on a ration having a nutrition ratio of 1:67.

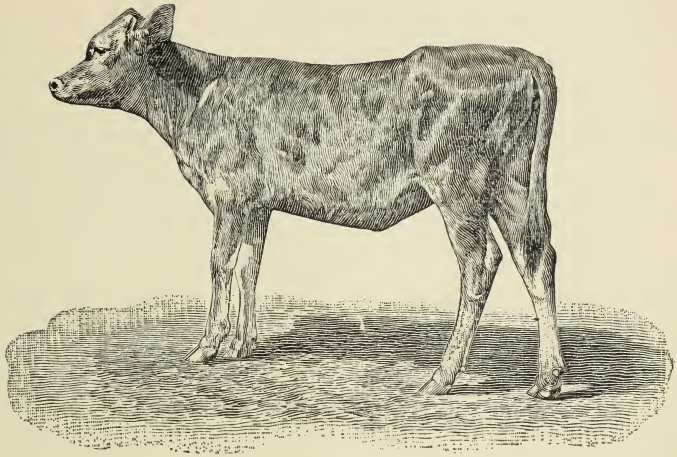
The fact that the cows in this trial maintained a uniform flow of milk and slightly increased the yield of fat during the progress of the experiment suggests that a ration of 1:69 gives satisfactory results.

RAISING DAIRY BRED CALVES.

T. L. HÆCKER.

Minnesota is destined to become one of the greatest dairy states in the Union, and since the dairy industry can be developed only in proportion to the increase of the number of cows, the rearing of calves for the dairy is a matter of vital importance. In all that vast territory north and west of the twin cities, there are but few localities within a radius of four miles where there are enough cows to warrant the organization of a co-operative creamery or cheese factory association. In such an extent of country where there is a demand for cows in nearly every neighborhood, the attempt to supply this demand by purchase is out of the question and our only remedy is to breed and rear the calves and in this way the demand for dairy stock can be gradually supplied. It is therefore to the interest of farmers of Minnesota to breed their cows to dairy sires and rear the heifer calves. The importance of having stock intended for the dairy produced by dairy sires is forcibly illustrated in another part of this bulletin, where it is shown by actual experiment with twenty-three cows, on a years' trial, that the dairy bred cows produced on an average 337 pounds of butter fat at a cost of 11.6 cents per pound, while the cows having a tendency to convert feed into beef on practically the same ration gave, on an average, only 267 pounds of butter fat, costing 13.8 cents per pound. There are now and then good dairy animals produced by sires belonging to beef or general-purpose breeds, but they are exceptional cases. The great majority of the offspring will be a failure in the dairy.

The calves reared in this trial were all of the dairy type and with three exceptions converted all of their feed into growth. The object of the experiment was to compare



No. 6. YOUNG HOUSTON.

the cost of raising calves on whole milk and on skim milk supplemented with a feed of flax seed meal—ground flax, and to note the thriftiness of the calves raised on the two kinds of feed. This experiment was undertaken after fifteen years' experience in raising dairy calves as a business and therefore not without certain settled convictions as to the best methods of procedure.

The calf was allowed to suckle the dam once and in some instances twice. It was then taken from the dam and one feeding period allowed to pass without offering the calf any milk. The object in doing this was to get the calf to drink readily without the finger. During the first week the calf was fed twice a day as much of the dam's milk as was considered sufficient to keep it in a thrifty condition. To insure uniform feeding the milk was weighed as soon as drawn from the cow and given to the calf at once. During the second week the feed was half whole milk from the dam and half fresh separator skim milk. The third week, if in a thrifty condition, it received separator skim milk with a table-spoonful of ground flax. If a little delicate it received one-third whole and two-thirds skim milk. The ration of skim milk and ground flax seed was gradually increased according to the growth of the calf.

Nine calves were in the trial, one was fed on whole milk during a period of 61 days while eight were changed to skim milk as indicated above.

TABLE XXXVI.—Record of Calf No. 1.

Period of Four Weeks.	FEED. Milk				Cost for period	Weight	Gain in weight	Average daily gain	Cost of 1 lb. gain
	Lbs.				$	Lbs.	Lbs.	Lbs.	Cts.
First	364				3.64	115	30	1.07	12.15
Second	504				5.04	190	75	2.68	6.71
*Third	520				5.20	245	55	1.96	10 20
Total	1388				13.88	245	160		
Average								1.96	9.69

*Last period only three weeks and five days.

The time is divided into periods of four weeks each. During the first, second and third week of the first period the calf received 12 pounds of milk daily and during the fourth week it received 16 pounds of milk each day. During four weeks it took 364 pounds of whole milk and gained thirty pounds in growth, being an average daily gain in weight of 1.07 pounds; each pound of gain costing 12.15 cents, estimating milk at $1 per 100 pounds. During the first week of the second period it received sixteen pounds of milk daily, during the second and third week eighteen pounds, and during the fourth week twenty pounds. During the four weeks it received 504 pounds of milk and gained 75 pounds, being an average daily gain of 2.68 pounds, at a cost of 6.71 cents per pound. During the third period which covered only twenty-six days, it received twenty pounds of milk daily, gained 55 pounds at a cost of 10.2 cents per pound; the average daily gain being 1.96 pounds.

The total amount of whole milk taken was 1,388 pounds, total gain 160 pounds and the average cost per pound gain was 9.69 cents. The calf consumed $13.88 worth of milk and was then sold for veal bringing $7.20, being a loss of $6.68.

During a year's trial, in which every cow in the station herd was included, it was found that the average cost for producing a hundred pounds of milk was 61 cents. Applying this cost to the amount of milk taken by the calf instead of the value of a hundred pounds of milk, we find that the calf took $9.79 worth of milk leaving a net loss of $2.40.

TABLE XXXVII. Record of Calf No. 2.

Period of four weeks	Feed					Cost for period	Weight	Gain in weight	Average daily gain	Cost of 1 lb. gain
	Milk	Skim milk	Flax meal	Oats	Hay					
	lbs.	lbs.	lbs.	lbs.	lbs.	$	lbs.	lbs.	lbs.	cents
First	88	310	1.96			1.40	103	43	1.53	3.27
Second		462	4.41			.81	127	24	.86	3.36
Third		504	8.26	21	42	1.27	160	33	1.18	3.84
Total	88	1276	14.63	21	42	3.48	160	100		
Averaga									1.19	3.49

Calf No. 2 was a full blood Jersey. During the first two days it received 10 pounds whole milk daily. During the other five days it received 8 pounds whole milk and 4 pounds skim milk. During the first two days of the second week it received 4 pounds of whole milk and 8 pounds of skim milk daily and during the balance of the week it received 4 pounds whole milk and 10 pounds skim milk. During the second and third weeks it received 16 pounds of skim milk per day and 1 pound of flax seed meal per week. It gained 43 pounds in weight during the period, being an average daily gain of 1.53 pounds at a cost of 3.27 cents per pound of gain. During the second period it received 462 pounds of skim milk, 4.41 pounds of flax seed meal, gained 24 pounds in weight being an average daily gain of .86 of a pound at a cost of 3.36 cents per pound of gain. During the third period it received 504 pounds of skim milk, 8.26 pounds of flax seed meal, gaining 1.18 pounds per day at a cost 3.84 cents per pound. The total gain during the three periods was 100 pounds, being an average daily gain of 1.19 pounds. The total cost for feed during the 84 days was $3.49.

TABLE XXXVIII.—Record of Calf No. 3.

Period of four weeks.	Feed.				Cost for period	Weight	Gain in weight	Average daily gain	Cost of 1 lb. gain
	Milk	Skim milk	Flax seed	Oats					
	lbs.	lbs.	lbs.	lbs.		lbs.	lbs	lbs.	cents
First	126	182	.98	.....	1.49	.95	40	1.43	3.72
Second	.....	462	5.53	1.40	.85	127	32	1.14	2.66
Third	.....	462	6.72	4.62	.90	163	36	1.18	2.51
Fourth	.....	448	7.70	7.28	.90	207	44	1.57	2.04
Fifth	.....	448	5.88	11.90	.93	234	27	.96	3.46
Total	126	2002	26.81	25.20	5.07	234	179	.....	.....
Average	.....	.....	.....	.....	.....	.....	.....	1.28	2.88

Calf No. 3 was a cross bred Jersey-shorthorn. It was changed gradually from whole milk to skim milk. During the first week it received eight pounds whole milk per day, during the second six pounds whole milk and six pounds skim milk, during the third week four pounds whole milk and eight pounds skim milk, and during the fourth week it received twelve pounds skim milk per day. The gain in weight during the first period of four weeks was 48 pounds, being an average gain of 1.43 pounds per day at a cost of 3.72 cents per pound. During the first two weeks of the second period it received sixteen pounds of skim milk daily and from .17 to .20 of a pound of flax seed and during the third week it received daily sixteen pounds skim milk and .20 of a pound of flax seed meal, and during the fourth week eighteen pounds skim milk and .2 pounds flax seed meal. During the second period it received 462 pounds skim milk, 5.53 pounds flax seed and 1.4 pounds of whole oats, gaining during the four weeks 32 pounds, at a cost of 2.04 cents per pound. During the third period the milk was gradually increased to 18 pounds and the flax meal to .25 of a pound, aggregating during the period 462 pounds skim milk, 6.72 pounds ground flax and 4.62 pounds oats, the calf averaging a daily gain of 1.28 pounds at a cost of 2.51 cents per pound. During the fourth period it received 448 pounds of milk, 7.70 pounds flax meal and 7.28 pounds oats, making a gain of 44 pounds

at a cost of 2.04 cents per pound. During the fifth period the ground flax was decreased to 5.88 pounds and the oats increased to 11.9 pounds and it gained only 27 pounds at a cost of 3.46 cents per pound. During this period it had an attack of scours brought about possibly by feeding too much flax meal. This calf made good growth and laied on some flesh. With a single exception it made a greater average gain than the other calves fed on skim milk, and the cost of growth was only 2.88 cents per pound.

TABLE XXXIX—Record of Calf No. 4.

Period of Four Weeks.	FEED.				Cost for Period	Weight	Gain in Weight	Average daily gain	Cost of 1 lb. gain
	Milk	Skim milk	Flax Seed meal	Oats					
	Lbs.	Lbs.	Lbs.	Lbs.	$	Lbs.	Lbs.	Lbs.	Cts.
First	84	252	2.17		1.20	105	33	1.18	3.63
Second		462	5.88	2.45	.87	127	22	.78	3.98
Third		462	7.00	5.11	.91	157	30	1.07	3.04
Fourth		448	7.98	8.54	.95	189	32	1.14	2.97
Fifth		448	4.20	12.25	.89	205	16	.57	5.58
Total	84	2072	27.23	28.35	4.82	205	133		
Average								.95	3.84

Calf No. 4 was a grade Guernsey. During the first week it received 8 pounds of whole milk daily, during the second week 4 pounds of whole milk and 8 pounds of skim milk, during the third week 12 pounds skim milk and during the fourth week 16 pounds, aggregating during the first period 84 pounds whole and 252 pounds skim milk, and 2.17 pounds ground flax, and it gained 33 pounds in weight at a cost of 3.68 cents per pound. During the second period it received 462 pounds of skim milk, 5.88 pounds ground flax and gained 22 pounds, costing 3.98 cents per pound of gain. During the third period with the same amount of skim milk and a slight increase in the meal it gained 30 pounds at a cost of 3 cents per pound while during the fourth period it gained only 16 pounds at a cost of a trifle over 5.5 cents per pound of gain. The calf during the second and fifth periods

had an attack of scours which accounts for the small gain made. The cost of growth during the twenty weeks was 25 cents less than calf No. 3, but the cost per pound of growth was about one cent more.

TABLE XL. Record of Calf No. 5.

Period of Four Weeks.	Feed.				Cost for period	Weight	Gain in weight	Average daily gain	Cost of 1 lb. gain
	Milk	Skim milk	Flax seed	Oats					
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
First	112	252	2.17	.....	1.48	115	30	1.07	4.94
Second	.....	462	5.88	2.45	.87	144	29	1.03	3.02
Third	.....	462	7.00	5.11	.90	165	21	.75	4.33
Fourth	.....	448	7.98	8.54	.95	203	38	1.36	2.49
Fifth	.....	448	4.20	12.25	.89	235	32	1.14	2.79
Total	112	2072	27.23	28.35	5.10	235	150	.....	.....
Average	.....	.....	.....	.....	.....	.....	.....	1.07	3-51

Calf No. 5 was a grade Holstein and was fed the same as No. 3 with the exception that it received 12 pounds of whole milk the first week. It made moderate growth during the twenty weeks of the trial except a few days during the third period when digestion was impaired by feeding the milk at too low a temperature. The calf was fat when it was dropped and continued to lay on flesh during the experiment. It was heavy in shoulders and full in thighs.

TABLE XLI--Record of Calf No. 6.

Period of Four Weeks.	FEED.				Cost for period	Weight	Gain in Weight	Average daily gain	Cost of 1 lb. gain
	Milk	Skim milk	Flax Seed meal	Oats					
	Lbs.	Lbs.	Lbs.	Lbs.	$	Lbs.	Lbs.	Lbs.	Cts.
First	182	168	.98	.....	2.10	110	45	1.60	4.79
Second	.....	448	5.53	.....	.81	145	35	1.25	2.31
Third	.....	476	6.72	4.62	.92	160	15	.54	6.08
Fourth	.....	462	7.70	6.30	.94	196	36	1.29	2.61
Fifth	.....	448	7.84	11.20	.96	231	35	1.25	2.74
Sixth	.....	448	1.96	14.70	.85	257	26	.93	3.26
Total	182	2450	30.73	36.82	6.58	257	192	.....	.....
Average	.....	.....	.....	.....	.....	.....	.....	1.14	3.47

Calf No. 6 was a cross-bred Jersey-Guernsey. It was a model in form from a dairy standpoint, being spare; deep through the middle and flank, light in the fore quarters and unusually large in hind quarters. To show the condition of the calf at the close of the experiment and its conformation, an illustration is given at the head of this article Its dam is Houston, see page 61 of this bulletin. The calf made rapid growth during the experiment except in the third period when its was checked by taking too much skim milk during the second week. During the first, it received 10 pounds whole milk, during the second week 12 pounds and during the third 4 pounds whole milk and 8 pounds skim milk. During the remainder of the trial it received 16 pounds skim milk daily except in the first and second week of the third period when it received 18 pounds daily which proved a little too much. It received ground flax and oats the same as did the other calves in the trial. During the six periods the feed cost on an average $1.10 for a period being a trifle over 25 cents per week. It gained on an average 1.14 pounds per day at a cost of 3.47 cents per pound of growth.

TABLE XLII.—Record of Calf No 7.

Period of Four Weeks	Feed					Cost of period	Weight	Grain in weight	Average daily gain	Cost of 1 lb. gain
	Milk	Skim milk	Flax seed	Bran	Oats					
	lbs.	lbs.	lbs.	lbs.	lbs.	$	lbs.	lbs.	lbs.	lbs.
First	154	196	1.68	....	.....	1.87	131	49	1.75	3.82
Second	112	280	.....	.....	.....	1.54	197	66	2.34	2.35
Third	.....	490	.....	.....	.....	.78	250	53	1.89	1.48
Fourth	... .	546	.....	10.5	.....	.96	330	80	2.86	1.20
Fifth	.....	560	.....	14	.....	1.01	390	60	2.14	1.68
Sixth	.....	560	.....	.....	14	1.16	420	30	1.07	3.87
Total	266	2632	1.68	24.5	14	$7.32	420	338	... .	....
Average	.....	....	.....	.....	....	.....	.....	.....	2.01	2.40

Calf No. 7 was a full blood Holestein-Friesian, it was large and in good condition when it was dropped. was a

hearty feeder and showed strong digestive powers. During the first week it received 12 pounds of milk daily, during the second 10 pounds of whole milk and 4 pounds of skim milk, and during the third and fourth 12 pounds of skim milk and some flax meal. During the period of four weeks it gained 49 pounds, being an average daily gain of 1¾ pounds at a cost of 3.82 cents per pound. During the second period it received 4 pounds whole milk and 10 pounds skim milk daily and gained 66 pounds, being an average daily gain of 2.34 pounds at a cost of 2.35 per pound. During this period it gained in flesh and to prevent this in the third period no whole milk was given. It made an average gain of 1.89 pounds per day at an average cost of a trifle less than 1.5 cents per day. The fourth period it received 546 pounds of skim milk and 10.5 pounds of bran and an equal amount of corn meal gaining 80 pounds at a cost of 1.2 cents per pound. The average gain during the six periods was a trifle over 2 pounds per day at an average cost of 2.4 cent per pound.

TABLE XLIII.—Record of Calf No. 8.

Period of Four Weeks	Feed					Cost for period	Weight	Gain in weight	Average daily gain	Cost of 1 lb. gain
	Milk	Skim milk	Flax meal	Bran	Corn meal					
	lbs.	lbs.	lbs.	lbs.	lbs.	$	lbs	lbs.	lbs.	cents
First	98	238	.84			1.36	100	40	1.41	3.44
Second		350	4.13			.64	127	27	.96	2.37
Third		350				.53	154	27	.96	1.96
Fourth		504				.81	195	41	1.46	1.98
Fifth		560		14	14	1.02	240	45	1.61	2.26
Sixth		560		10.5	10.5	.97	270	30	1.07	3.23
Total	98	2562	4.97	24.5	24.5	5.33	270	210		
Average									1.25	2.54

Calf No. 8 was a full blood Jersey. During the first week it received 10 pounds of whole milk daily, but not being weighed this week is not included in the above record. During the second week, which is the first week it was in

the experiment, it received 8 pounds of whole milk and 4 pounds of skim milk with the usual amount of flax seed meal. It made rapid growth and laid on some flesh. During the second period it received 350 pounds of skim milk and 4.13 pounds of ground flax. It still continued to lay on flesh so the ground flax was discontinued in the third and fourth periods. It made excellent growth during the eighth week gaining 68 pounds at an average cost of 1.97 cents per pound. The average daily gain during the trial was 1¼ pounds per day at a trifle over 2.5 cents per pound.

TABLE XLIV.—Record of Calf No. 9.

Period of Four Weeks	Feed					Cost for period	Weight	Gain in weight	Average daily gain	Cost of 1 lb. gain
	Milk	Skim milk	Oats	Hay	Bran					
	lbs.	lbs.	lbs.	lbs.	lbs.	$	lbs.	lbs.	lbs.	lbs.
First	98	182				1.30	120	48	1.71	2.71
Second		504				.76	150	30	1.07	2.53
Third		504	28			1.01	190	40	1.41	2.56
Fourth		504	21	14	3.5	1.00	220	30	1.07	3.34
Fifth		182		98	38.5	1.14	240	20	.71	5.73
Sixth				168	56	1.34	265	25	.89	5.37
Total	98	1876	49	280	98.0	6.5 5	265	193		
Average									1.14	3.71

Calf No. 9 was out of grade shorthorn cow by a Jersey sire. In conformation it resembled the sire, and showed little, if any, tendency to lay on flesh. During the first period it received 98 pounds of whole milk, 182 pounds of skim milk and 1.68 pounds of ground flax and gained 1.71 pounds per day at a cost of 2.71 per pound. During the fifth and sixth periods it received in addition to the feed stuffs recorded in the table, 50 pounds of corn meal and 44 pounds of linseed meal which is included in the cost for feed. The calf made satisfactory growth except in the last two periods, when the skim milk was gradually withdrawn. During the time when no skim milk was fed the average cost of a pound of gain was 5.5 cents. The

cost of a pound of growth when whole milk was fed was 9.69 cents, while the average cost of a pound of growth of the calves fed on skim milk and ground flax was 3.23 cents.

The following table gives a general summary of results:

TABLE XLV.—Summary.

	Days in trial	Cost	Weight	Gain in weight	Average daily gain	Cost of 1 lb. gain
		$	lbs.	lbs.	lbs.	cents
Calf No. 1	61	13.88	245	160	1.90	9.69
" " 2	84	3.48	160	100	1.19	3.49
" " 3	140	5.07	234	179	1.28	2.88
" " 4	140	4.82	205	133	.95	3.84
" " 5	140	5.10	235	150	1.07	3.51
" " 6	168	6.58	257	192	1.14	3.47
" " 7	168	7.32	420	338	2.01	2.40
" " 8	168	5.33	270	210	1.25	2.54
" " 9	168	6.55	265	193	1.14	3.71
Average for calves fed on skim milk					1.25	3.23

The flax seed meal was analyzed with following results:

Water 6.11 per cent; dry matter 93.89 per cent. Composition of dry matter:

Ash.....4.03	Ether extract.....40.56
Crude Proetin....23.12	Crude Fiber..... 8.02
Nitrogen free ex.....24.27	

While the experiment was fairly satisfactory as to the general growth of the calves, the details in feeding were not as carefully carried out as the importance of the word required. It is therefore being repeated with a view of obtaining more accurate data, though it can hardly be expected that our efforts will result in growing a finer lot of calves.

CO-OPERATIVE CREAMERIES.

T. L. HÆCKER.

The great interest that has been awakened in the minds of farmers of Minnesota on the subject of diversified farming brings so many letters making inquiry as to best methods of organizing co-operative creamery associations that it is found impracticable to answer them all in detail by letter. It is therefore thought best to offer such suggestions and give such information as will place this industry on a firm basis. That intelligent dairying is a profitable business needs no argument; demonstrated results are more convincing than words; the results in Freeborn and Steele counties have settled this question for all time so far as our state is concerned. It should, however, be remembered that there are creameries and cheese factories idle in Minnesota, which is also conclusive proof that such enterprises are not always a success, and that the causes of such failures should be considered, After a thorough canvass of the state it was found that about half of the vacant factories are in localities where there are not a sufficient number of cows; others failed because they were owned by individuals who did not pay enough for cream to make it an object for the farmers to patronize them. As a rule the gathered cream plan, where old methods of setting milk were used, did not give satisfactory returns to farmers; but whenever separator creameries have been established on the co-operative plan, in localities where there are a sufficient number of cows within a radius of four miles, they have in every instance secured highly satisfactory results. Therefore when considering the advisability of starting a creamery in any locality, the first thing to do is to ascertain if the required number of cows can be secured within a radius of four or five miles, which is about as far as milk can profitably be hauled. If less than four hundred cows are secured we would advise that the project be dropped, as it is difficult to make it a success with less.

ORGANIZATION.

If the required number of cows can be pledged within the limits prescribed the next thing is the organization. In this matter as in most all other enterprises it is well to follow the course pursued by the successful creameries. One of the chief agencies of success in the Freeborn county creameries is their method of organization. They do their own oganizing and have nothing whatever to do with agents who are going through the country offering to work up a creamery company in any neighborhood, soliciting the stock and getting out the articles of incorporation, building the creamery and equipping it and turning it over to an association of farmers at a given price. This of course seems like a very nice way, as it relieves the members of the creamery association of all the preliminary work in the organization of the creamery, but it is expensive as outside parties can not do it so cheaply and effectively as it can be done by the farmers living in the neighborhood. In the long run it is not to the interest of supply houses to do this part of the work, for in every case where these ready built and equipped creameries have been turned over to the farmers they soon discovered that they paid from $500 to $2,000 more for the plant than it was worth, which creates dissatisfaction with the house they dealt with and it loses their trade.

HOW TO RAISE THE MONEY.

The old plan of providing funds for building creameries was for each patron to take one or more shares of stock, paying the cash for them. In many communities it has been found difficult to raise the money under this plan, as many desirable patrons were unable to raise the amount of cash required to build and equip a creamery.

To overcome this difficulty let each patron of the proposed creamery sign an agreement drawn after the form given below marked "Organization Agreement," signing his name, and the number of cows he will agree to furnish milk from, to the creamery.

You will notice this agreement provides for borrowing the amount of money necessary to build the creamery, and

that each person signing the agreement, agrees to be responsible for the payment of the sum borrowed. There is hardly a community in the state in which some one cannot be found who would be willing to loan $2,000, more or less, to an association of twenty-five, or fifty, or more, farmers, each one of whom agrees to be personally responsible for the loan.

When the required number of patrons and cows have been secured, call a meeting of the patrons and perfect the organization by adopting and signing articles of agreement. We give below articles af agreement and by laws, which are in use by the Freeborn county creameries, and have been found to be very satisfactory. Of course such changes could be made in these as might be desired. It will be noticed that article two of the by laws, provides that five cents on each one hundred pounds of milk received at the creamery shall be retained to form a sinking fund, to be used to pay off the money borrowed. And, that article four of the agreement authorizes the Board of Directors to borrow the sum required, the loan to be paid back out of the sinking fund as fast as it is accumulated.

This plan enables the creamery association to start without the individual patrons being required to raise the cash, and at the same time it gives the creamery the ready cash to buy their lumber, materials and machinery, so as to obtain the benefit of the lowest cash prices.

The five cents per hundred pounds that is deducted from the amount of milk taken to the creamery is not felt by the patrons, as even after this is taken out they will get more out of their milk than they have been getting by making it into butter themselves, so that the creamery is gradually paying for itself, without expense to the patrons.

Under this plan, a creamery that is receiving milk from five hundred cows should be getting ten thousand pounds of milk a day, if five cents per hundred of this went into the sinking fund, it would be five dollars a day; so that it would require from a year to a year and a half to pay off the loan, and have the creamery clear under this plan, on a creamery receiving the amount of milk stated above.

The following agreement of organization, articles of association and by laws are used by the Freeborn county creameries:

ORGANIZATION AGREEMENT.

We, the undersigned citizens of .....county, state of Minnesota, do hereby agree to form ourselves into an Association to be known by the name of the .....Association, and we agree to borrow the sum of ..... dollars, or less, to put up a building and equip it with the necessary machinery, and jointly, to become personally responsible for the sum borrowed including interest. The money to be raised in the manner agreed upon by the Association. We also agree to furnish the milk from the number of cows opposite our names.

NAME.	COWS.

ARTICLES OF AGREEMENT OF THE.....ASSOCIATION.

We, whoss names are hereunto subscribed, and whose residences are within the county of ..... in the state of Minnesota, do hereby associate ourselves together as a co-operative association under the laws of the state of Minnesota, and have adopted the following constitution, viz:—

ARTICLE I.

The name of the Association shall be the ..... Assoeiation and its place of business shall be at or near Section ..... in the Town of ..... in said..... county.

ARTICLE II.

The object of this Association shall be the manufacture of butter or cheese or both from whole milk, at actual cost.

ARTICLE III.

The officers of this Association shall be a President, Vice-President, Secretary, Treasurer and three Trustees, who shall be elected annually at the regular annual meeting of the Association to be held on the first Monday of January of each year and their term of office shall be one year and until their successor shall have been duly elected and qualified.

ARTICLE IV.

The duties of the respective officers shall be as follows:—The President shall preside at all meetings of the Association, sign all drafts and pay over to the Treasurer all moneys which shall have come into his possession by virtue of his official position, taking the treasurer's receipts therefor.

He shall have power to call special meetings of the Association whenever in his judgment the business of the Association shall require it.

The Vice President shall perform the duties of the President when he is absent or otherwise unable to attend to them.

The Secretary shall keep a record of all the meetings of the Association, and make and sign all orders upon the Treasurer.

The Treasurer shall receive and receipt for all moneys belonging to the Association and pay out the same only upon orders which shall be signed by the Secretary; he shall give bonds in such amount as the Association shall provide.

The President, Vice President, Secretary and Treasurer and three Trustees shall constitute a Board of Directors, whose duties shall be to audit and allow all just claims against the Association. They shall compute the amount of milk receipts, the amount of product sold and the moneys received therefor, and, after deducting from the total receipts the percentage herein provided for as a sinking fund and also the running expenses, on the 20th day of each month, divide the remaining receipts of the preceding month among the members and patrons of the Association, proportionally to the amount of whole milk or fat furnished by each. Provided, however, that in case of the withdrawal of any member from this Association before the moneys herein provided to be borrowed shall have been paid in full, principal and interest, all product from milk furnished by such withdrawing members then on hand, and any moneys received from such product then in the possession of the Association shall be retained until all such moneys so borrowed shall have been fully repaid, and thereafter said moneys, or any remainder thereof after applying the just share of such withdrawing members therefrom to the repayment of any balance of such indebtedness not paid from the sinking fund, shall be paid over to him or his assigns.

The Board of Directors shall cause the Secretary to make, in writing a report to the annual meeting to the Association, setting forth in detail the gross amount of milk receipts, the net amount of receipts from product sold and all other receipts, the amount paid out for running expenses, the sums, if any, paid out for milk, and all other matters pertaining to the business of the Association. A like statement, containing the gross amount of milk receipts, the net receipts from product sold and all running expenses of the creamery shall be made and posted conspicuously in the creamery building at the time of the division of the prior month's receipts as aforesaid.

The Board of Directors shall borrow a sum of money not exceeding .... Thousand Dollars, to be used by them in the erection, completion and furnishing of the creamery building and for no other purpose. Said members of said board may borrow said money on their individual responsibility, and in case they shall do so, then the sinking fund herein provided for shall by them be applied in payment of such borrowed moneys as the same fall due in the same manner as though said moneys had been borrowed by the Association. Said members of the board in

such case shall be held to be the creditors of the Association to the amount of such moneys unpaid, and the several members of said Association shall be personally responsible, jointly and severally, for the same. Provided, however, that prior to any legal assertion of such individual responsibility, the entire sinking fund then accrued and on hand shall be applied upon such indebtedness: And, provided further, that said members so borrowing said moneys may if they so elect, demand and receive any part or all of the moneys received from product sold, then in the possession of the Association, upon such indebtedness before enforcing such personal responsibility. In which case only that part of such indebtedness remaining after applying thereon all sums so received shall be recovered or demanded from the members of the Association.

ARTICLE V.

The several members shall furnish all the milk from all the cows subscribed by each, all milk to be sound, fresh, unadulterated, pure and unskimmed, and patrons of the Association not members, may by agreement with the Board of Trustees furnish such amounts of milk as may be agreed upon. The Association shall receive all such milk so furnished, manufacture the same into butter, cheese or both and sell and receive all moneys from the product; and from the moneys so received deduct such a percentage thereof, or such a number of cents per one hundred pounds of milk as shall have been agreed upon by the Association in the by-laws or otherwise, and also deduct the running expenses of the creamery, the remainder thereof to be distributed as provided in Article IV. hereof.

ARTICLE VI.

Each member shall be entitled to one vote only at any meeting of the Association. New members may be admitted as provided in the By-laws. Members shall be permitted to withdraw only as provided in the By-laws.

ARTICLE VII.

The first officers and Board of Trustees shall be as follows: ..... President; .....Vice President; ..... Secretary; .....Treasurer; .... Trustees.

ARTICLE VIII.

The constitution may be amended at any annual meeting, or at any special meeting called for that purpose, provided that two-thirds of all members present vote in favor of such change; and provided further, that at least one month's notice of such proposed amendment shall have been given in such manner as may be provided in the By-laws, or otherwise by the Associations.

NAMES.

BY-LAWS OF THE.....ASSOCIATION.

I.

The Treasurer shall give bonds in the sum of.....dollars the bond to be approved by the Board of Directors.

II.

Five cents on each one hundred pounds of milk received at the creamery shall be reserved to form a sinking fund.

III.

No milk shall be received or business of any kind transacted at the creamery on Sundays.

IV.

During the interval between the twentieth day of May and the twentieth day of September of each season all milk shall be delivered at the creamery as early at least as nine o'clock a.m.; during the remaining portion of the season as early as ten o'clock a.m.

V.

All milk delivered shall be sweet and in good condition; if any be found otherwise, the operator may condemn the same, and in such case he shall notify the President thereof. The operator shall test the milk of each member and patron at least three times a week.

VI.

Any member or patron of the Association found skimming, watering or in any manner adulterating his milk offered at the creamery shall forfeit to the Association as follows: For the first offense ten dollars; for the second offense, twenty-five dollars; for the third offense he or she shall forfeit all interest in the Association and also all claims for milk theretofore delivered to the Association. But no such forfeiture shall be adjudged without first affording to the member or patron charged with having so skimmed, watered or adulterated his milk, full opportunity to defend himself from such charge. Any member sending to the creamery any bloody or unhealthy milk, or any milk from any cow within four days after calving, shall, if convicted of having so done knowingly, forfeit as prescribed above in this section.

VII.

Members and patrons furnishing whole milk may take from the separator or the tank at the creamery four-fifths of the quantity of milk (in

pounds or quantity) delivered at the creamery by them on that day. Any member taking therefrom more than such amount shall forfeit to the Association the sum of five dollars for each such taking.

VIII.

Withdrawals from the Association shall be allowed only as follows:— The member desiring to withdraw shall give at least one month's notice of his application therefor. Such application shall only be allowed on a vote of two-thirds of all members present and voting at any meeting for hearing at which such application shall have been noticed. Provided, however:— That any member living more than three miles by the nearest road from the creamery building, may make application to the Board of Directors, who in their discretion may grant permission to such member to withdraw from the Association.

IX.

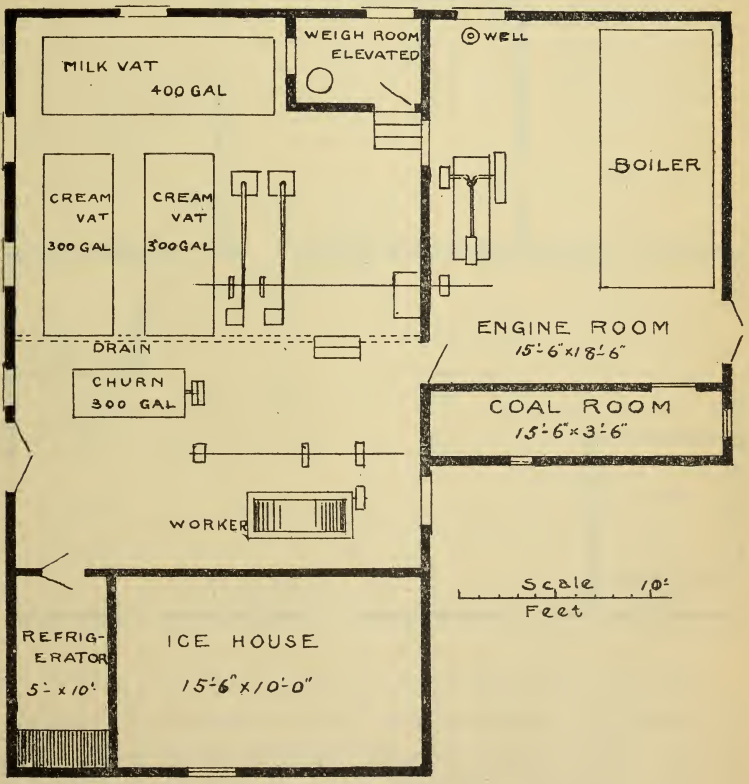
Any member refusing to deliver at the creamery the milk agreed to be there delivered, shall, without reasons satisfactory therefor to the Association, forfeit all interest in the product on hand.

X.

Notice of any proposed amendment to the Constitution shall be in writing or printing and shall be kept posted prominently in the creamery building and also on the walls of the delivery department for the reception of milk.

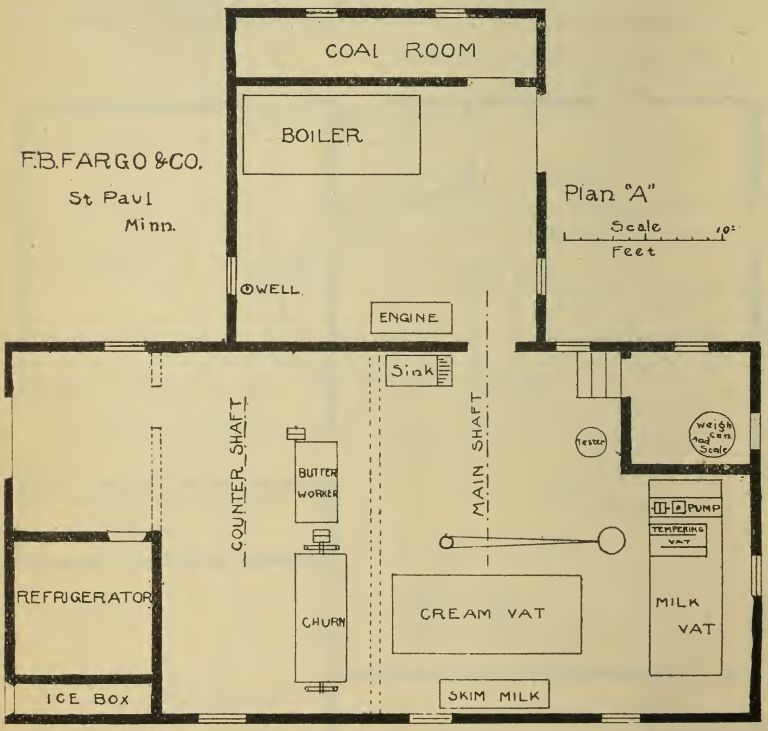
THE CREAMERY BUILDING

After the organization of a creamery association the universal inquiry is: "What kind of a building is it necessary to construct and can you furnish us plans for same?" In order that we may be able to intelligently answer these inquiries we requested the creamery supply houses in the state to furnish us with a plan of a model creamery building; in reply to this request two of the firms have kindly responded and the plans are given below.



GROUND PLAN OF CREAMERY
CREAMERY PACKAGE MFG. CO
MANKATO MINN.

Plan No. 1, which is furnished by the Creamery Package Company, of Mankato, provides for a creamery 20x38 with an engine and boiler and coal room 16x22 and will cost from $600 to $800 according to location and if stone and lumber is brought to the creamery site by the members of the association. The equipments of the creamery will cost from $1500 to $2000 according to the number of separators.



Plan No. 2.

Plan No. 2 is furnished by F. B. Fargo & Co., of St Paul. The building is 44 feet long by 22 feet wide and 12 feet to the ceiling. Boiler, coal and engine room on side of building 20x 20 feet, equipped with separator capacity of 20,000 lbs. of milk daily, and all other machinery with capacity of 20,000 lbs. milk daily or butter capacity of 800 lbs. daily.

ESTIMATE OF COST.

Foundation (mason, brick and cement)	$ 60 00
Lumber (delivered on ground)	570 00
Hardware	35 00
Carpenter work	175 00
Grading for drive way (estimate level ground)	20 00
Painting	40 00
Machinery, including all steam and water pipe and fitting, and all belting as per usual lists of one separator outfit	1,500 00
Freight on same (estimate 100 miles)	50 00
Drayage (in town)	10 00
Machinest to set up all machines (estimate 10 days)	30 00
Brick, lime and cement to set boiler and engine in boiler room	115 00
Mason work to set boiler and engine	35 00
Extra labor handling boiler and engine	10 00
Iron roof for boiler room	20 00
Butter milk tank and drain	20 00
Waste water drain (estimate 10 rods)	10 00
Galvanized iron for ice box in refrigerator and ice box	20 00
Radiating steam pipe put in place sufficient to heat entire building	85 00
Incidental expenses	75 00
	$2,880 00

The above estimate does not include well, but it includes pump and pipe.

The farmers in the neighborhood of Geneva, Freeborn county have what they consider a model creamery. It has two good separators and is in every respect equipped with the best apparatus and cost $2,800 when ready for receiving milk. There will be many new creameries built the coming season and it is of great importance that farmers inform themselves as to the size and kind of building best adapted for their purpose as well as to what the necessary cost will be.

MANUFACTURE OF SWEET CURD CHEESE.

T. L. HÆCKER.

One of the objects of the Division of Dairy Husbandry is to develop new avenues for this industry. Noting the great demand in the larger cities in the state for some foreign brands of cheese at highly remunerative prices it was deemed of sufficient interest to offer instruction in the manufacture of a few of the most popular kinds at the Minnesota Dairy School. The plan received the hearty approval of the regents of the university and Hon. John Luchsinger of Monroe, Wis., was engaged to take charge of the manufacture of Emmenthaler, brick and Limburger, and J. H. Hecker of Neenah, Wis., to give instruction in the manufacture of Gouda and Edam cheese. During the entire work a careful record was kept of the amount of milk used, the per cent of fat and other solids contained in the milk and the amount of green cheese obtained. Some difficulty was experienced in securing the apparatus necessary for the work and also in properly curing the cheese. The Dairy Hall is not supplied with curing rooms where either the temperature or moisture is under control to the extent that is necessary for best results. Notwithstanding these unfavorable conditions the cheese manufactured under the supervision of the instructors were uniformly of good quality and received high commendation from those best qualified to pass upon their merits. The result obtained seem to warrant a continuation of the work and the publication of the process of their manufacture with tables showing the composition of the milk and whey, the loss of fat and other solids in the whey and the relation existing between the per cent fat in the milk and the yield of green cheese. The milk and whey of each make was examined by chemical analysis

and from the data thus obtained the recovery of solids in the cheese was calculated. No effort was made to ascertain the composition of the cured cheese by actual analysis for the reason that the want of sufficient space and accommodations in the curing room made it impracticable to keep each day's make separate. The process of dressing also, in all but two instances, rendered it impossible to ascertain the exact amount of cured cheese obtained from a hundred pounds of milk. From the two exceptions noted it was found that the shrinkage which takes place during the process of curing is much greater than is generally supposed. In one case it was twenty-five and in another twenty-six per cent. The cheese from these two makes were salted in brine five days, at a temperature of 70 degrees Fahrenheit, and cured in a room held at a temperature of sixty degrees. The moisture in the air of the room ranged from 75 to 90 per cent of total saturation. These are as favorable conditions as can be reached ordinarily and the loss of weight may reasonably be expected to be as great as shown in these two trials.

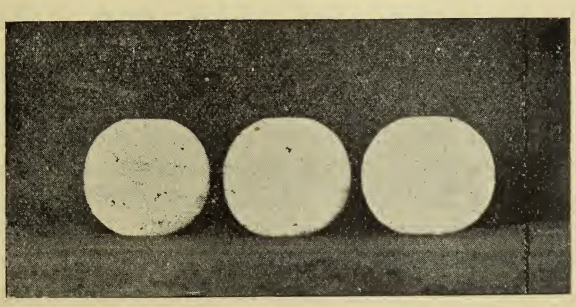


Fig. 1. Form of Edam Cheese.

The quality, size, form and general appearance of Edam cheese is a matter of considerable importance. Goods faultless in these respects will sell in our markets at top prices, while an article excellent in quality but undersized and defective in form will be shaded from two to three dollars per dozen. The term quality here, does not mean that the cheese must be made from milk containing a high percentage

of fat; but has reference to salt, flavor and texture. It is therefore of the utmost importance that the milk should be fresh, clean and pertectly sweet.

METHOD OF MANUFACTURING EDAM CHEESE.

Edam cheese is made from warm milk fresh from the cow, though sometimes it is made by mixing the evening's milk, after it is skimmed, with the morning's milk. If the evening's milk is used it must be set over night in ice water to hold in check the process of ripening. In the morning it is skimmed and warmed to 86 degrees Fahrenheit, and then the morning's milk is added. The mixed milk should be at a temperature of 86 degrees Fahrenheit, when the rennet is put in. If whole milk is used it is generally raised to 90 degrees before adding the rennet. In winter it is set at a little higher temperature. When the milk is warmed to the temperature desired, color is added at the rate of one or one and a half ounces of color to one thousand pounds of milk. We used from one and a half to two ounces of Hansen's cheese color to a thousand pounds, but this gave too high a color in the opinion of some who use and handle the best grade of imported Edam. Color should be thoroughly incorporated with the milk before rennet is added. It is not possible to state the exact amount of rennet that should be used as it varies in strength, but enough should be taken so the milk will commence to coagulate in five to seven minutes and should be ready for the knife in from fifteen to twenty minutes. We used from eight to ten ounces of Hansen's rennet extract per thousand pounds of milk. Dilute the rennet with about five times its volume of tepid water and in pouring it into the milk, pass over the whole length of the vat so that the rennet will not all be put in one end. Stir the milk with a large inverted dipper by moving it slowly through the milk the whole length of the vat so as not to give the milk a tide motion. Stir about one minute, then set the dipper on the surface of the milk a moment to check the agitation, then cover the vat until the curd is ready to

cut. To ascertain this insert the index finger into the milk at an angle of 45 degrees, with the thumb slightly break the curd laying over it, gently raise the finger and if the curd breaks clean leaving but few or no flakes it is ready to cut. A little practice will soon teach one when the curd cuts to best advantage. It should not be so firm that it will cut hard, neither should it be cut when it is too soft, as this occasions great loss of solids in the whey, yet the general tendency of the curd should be towards softness. The American curd knife is recommended as its use occasions less loss of fat and other solids. First cut with the horizontal knife lengthwise with the vat, then follow with the vertical knife as soon as the whey begins to appear between the layers of curd. Cut lengthwise of the vat with the vertical knife, then cut cross wise and lengthwise until the curd is cut into pieces the size of wheat kernels. The particles of curd adhering to the sides and bottom of the vat are now carefully rubbed loose.

After cutting, the curd should be allowed to settle a few moments ; stir gently for five minutes then apply heat, gradually raising the temperature to 98, though sometimes when the curd has not been cut finely or uniformly it is necessary to raise it to 102 deg. Fahrenheit. The curd is sufficiently cooked when it is firm and elastic, when the larger particles of curd are not soft and contain no free whey inside. It is difficult to give a full description of all the conditions bearing upon this part of the work; there should, however, be no unnecessary delay in getting the curd under pressure as the ripening process at this stage of the work is very rapid. When the curd is sufficiently firm it is allowed to settle, when the whey is drawn off until the upper surface of the curd begins to appear.

FILLING THE EDAM MOLDS.

Before the molds are filled they should be put in warm water so the curd will not be cooled during the process of filling. As soon as the whey is drawn fill the molds at once by taking a double handful of curd and pressing gently but firmly into the mold; as the filling progresses pour the whey out of the mold. Care should be taken to put the same

quantity into each mold to make the cheese perfectly spherical and of uniform size when pressed.

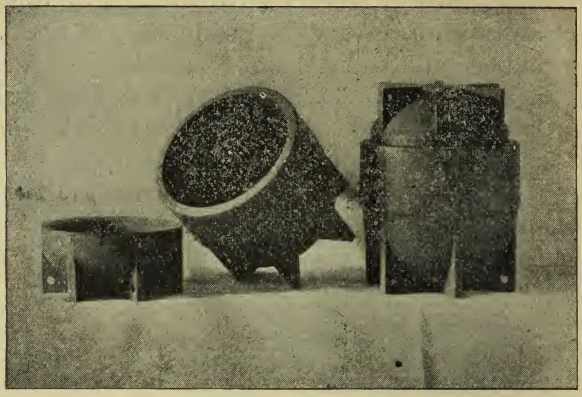


Fig. 2. Edam Molds.

The molds used at this Station are of cast iron, the pattern being made from an imported cheese of proper form. Figure 1 gives an illustration of some of the cheese made in these molds. The photograph was taken before they were dressed, so it gives the form of the cheese when first taken from the mold. They have a flattened surface on each end so they will set on the shelf without rolling. When the molds are filled, put under gentle, continued pressure for a sufficient length of time to make the cheese firm enough to retain its form while it is being dressed, which may require from fifteen to sixty minutes, according to condition of curd. When they are ready to dress set the molds containing the cheese into a vat of sweet whey or water at a temperature between 120 and 130 degrees Fahrenheit. Let stand for a minute before moving from the mold. Then take the cheese out place it in the warm water for one or two minutes then wrap a linen cloth around it, folding the edges carefully over on each side forming small pleats at regular intervals; put a linen cap on each end, replace in mold and put under pressure. The cloths and caps must be thoroughly soaked in the warm whey or water before applying to the cheese and care should be exercised that no part of the cheese remains un-

covered and that in returning it to the mold the bandage does not get displaced. If from any cause the curd seems to be tainted, washing in water at a temperature of 100 degrees Fahrenheit, before putting it in the mold will assist in freeing it from taint. Edam cheese does not require as much pressure as cheddar, 60 to 120 pounds will under ordinary conditions be sufficient. They should remain under pressure from six to twelve hours though no harm will be done if they are not taken out until the day following.

SALTING AND CURING.

When the cheese is taken from the press the molds are set in water at a temperature of 120 degrees Fahrenheit and allowed to stand for a few minutes. The cheese is then taken out and the bandage carefully removed, using care not to tear off any of the rind. The cheese is now ready for salting and for this, two methods may be employed, dry or wet salting. In dry salting it is necessary to have six salting molds to every press mold, these are made of wood, are quite similar in form to the press molds but require no cover. The inner surface of the salting mold is completely covered with a coating of salt, the cheese is then placed in the mold with a little sprinkling of salt on the upper part exposed to the air. This is repeated for five or six days turning them each day so they will settle into the proper shape.

If iron molds of the Minnesota Dairy School pattern are used, wet salting will be preferable, the cheese will have the proper form when taken out of the press, thus requiring less labor. In wet salting the cheese is placed in a tank of brine as strong as it can be made, a little salt is sprinkled on the upper end exposed to the air. The cheese should be turned each day and left in the brine five to eight days. The temperature of the brine may range from 60 to 70 degrees. Surface salting makes it exceedingly difficult to obtain uniformity, some day's make will take salt more readily than others, owing to the variation in the percentage of moisture in the curd. It is therefore especially important that the milk worked is fresh and that the cutting and cooking be as uniform as possible. When the cheese is sufficiently salted it is taken out of the brine and placed on a board to drain, for

twenty-four hours. It is then washed in warm water wiped dry and placed on the shelf for curing, leaving a little space between the cheese. Always set the cheese on the flattened end, turn and rub with the hand each day the first month, twice a week the second month and once a week the third month. The curing room should be cool and moist, the temperature should be held between 55 and 65 degrees, and there should be no sudden changes even within the temperatures given. Fresh air is also of prime importance though strong currents should not be allowed to come in contact with the cheese as it will cause cracking. If the air in a curing room becomes foul the cheese will become slimy or pasty and injurious fungi will soon develop. It the room is too damp bluish-yellow or red spots will appear which injure the quality of the goods and in extreme cases render it worthless.

PREPARING EDAM CHEESE FOR MARKET.

When the cheese is two or three months old it is prepared for market by turning it in a lathe until it is smooth and round, then colored with analine. The dye is made by dissolving a little analine or carmine in alcohol or ammonia. Take a two or three gallon jar, fill two-thirds full of water and add enough of the coloring matter to secure the desired shade. In this bath put the cheese for a minute or two then place on a shelf to dry and when dry give a light coating of boiled linseed oil. When in the coloring bath the cheese can be conveniently graded; the solid cheese will drop to the bottom, these are good keepers and belong to the best grade; those more open and of poorer quality will barely sink, while the ones that float are inferior goods. Cheese for export are wrapped with tinfoil in much the same way as in dressing; they are placed in boxes, each containing twelve cheese, in two layers of six each, the cheese being partitioned off with narrow boards.

The milk used in these experiments from Feb. 7th to the 15th was purchased from dealers and that used from the 19th of February to the 9th of May was from the station herd. That used during the latter period was not the mixed milk of the whole herd, but each make of cheese was from a

certain number, though not always the same cows, which accounts for the variation in the per cent of fat in the milk. The milk worked on the 7th of March, the 3rd, 5th and 7th of April and the 8th and 9th of May was two thirds whole and one-third skim milk. On and after the 10th of February fresh rennet extract was used, which will account for the change which took place as to the time of coagulation with the rennet test. The table is submitted simply to show the process of the make each day. There are a number of points which suggest further experiments and, if possible, more careful work. In Mann's acid test 50cc is the amount of milk used with one-tenth normal standard alkali. Comparing the figures in the fourth column with those in the fifth and taking those into account the temperature of the milk, it appears that the degree of acidity of the milk and the degree of the ripeness do not always run parallel. The degree of ripeness was ascertained by Monrad's modification of Harris' rennet test, as by this method more exact data can be obtained. It consists in diluting the rennet extract by putting 5cc (cubic centimeters) of rennet extract with a pipette into a flask measuring 5cc. then filling with cool water. Of this diluted rennet 5 cc. is added to 160 cc. of milk in a tin cup, at 86 degrees Fahr., the exact time elapsing between putting in the diluted rennet and when the milk commences to coagulate, indicates its degree of ripeness. In these experiments the aim was to have the milk in the vat commence to coagulate in seven minutes, excepting one vat on the 20th of February.

The morning's milk used the 3rd of April was tainted, so it was bailed occasionally for about an hour and a half and there being no improvement it was raised to a temperature of 158 degrees, then immediately cooled to 86 degrees, and some of Hansen's lactic ferment added, allowed to stand until evening, when the rennet test showed 20 sec., only 2 1-10 extract per 1,000 lbs. of milk was used; coagulation commenced in five minutes and it was ready for the knife in ten.

Comparing the time required until coagulation commences with that when ready for the knife the latter time will be found double the former. There in more regularity in

the figures indicating when coagulation commenced than in the time required for the curd to form sufficiently for cutting; this may be due to the fact that it is impossible to fix upon a uniform degree of firmness of the curd. By comparing the figures showing the amount of alkali required to neutralize the acidity in the milk with that required for the whey, it will be seen that the acidity in the whey was some 40 per cent less than in the milk.

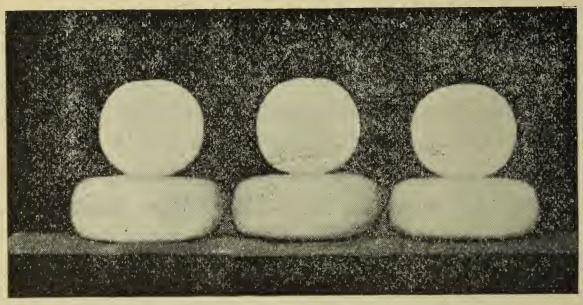


Fig. 3. Comparative Size of Edam and Gouda Cheese.

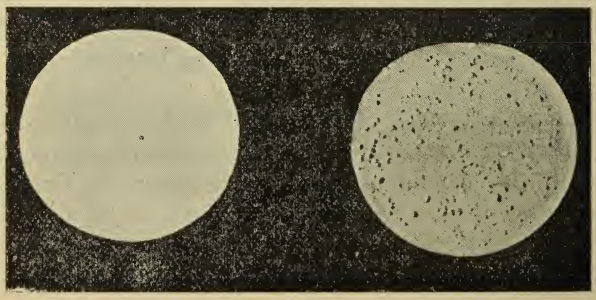


Fig. 4. Sectional view of Edam cheese made from good milk.

Fig. 5. Sectional view of Edam cheese made from tainted milk.

TABLE XLVI.—Processes and Principal Conditions in the Manufacture of Edam Cheese.

Date.	Lbs. of milk in vat	Per cent fat in milk	Amount of alkali necessary to neutralize acidity of milk	Rennet test for ripeness	Temp. of milk when test was taken	Amount of extract used per 1000 pounds of milk	Time required until coagulation begins	Time required until ready for knife	Temp. to which curd was heated	Time required to cook the curd	Amount of alkali necessary to neutralize acidity of whey	Time from adding rennet to putting to press	Weight of green cheese	Lbs. of milk to 1 lb. of cheese
1894			c.c.	secs.		ozs.	mins.	mins.		mins.	cc.	mins.		
Feb. 7	235.25	4.9	14	140	88°	15.6	7	16	94°	41	8.7	110	31	7.58
" 8	238.50	4.8	14	180	88°	8.9	7	20	95°	29	8.7	115	31.83	7.61
" 9	233.75	5.0	14.5	100	88°	11.6	6.5	18	100°	17	9.2	86	30.75	7.60
" 10	121	5.2	13	70	87°	11.0	5	17	96°	46	.....	92	16.87	7.17
" 14	156	4.7	13.5	85	88°	11.10	6	22	99°	64	.....	117	22	7.09
" 15	223.75	4.8	.....	70	89°	11.0	5	13	99°	65	8	90	31.12	7.12
" 19	115	4.9	13.5	60	94°	9.0	5	13	100°	34	8.3	79	16.12	7.13
" 20	50	5.1	.....	75	88°	3 0	15	35	101°	38	7.6	102	7.25	6.89
" 20	50	5.1	.....	75	88°	9.0	6.5	16	100°	43	7.6	84	7	7.14
" 28	83.5	4.7	12.4	85	88°	8.2	6	18	100°	48	7.6	91	11	7.60
Mch. 3	64	4.4	13	75	90°	8.9	7	13	100°	31	7.8	72	8.62	7.54
" 5	60	5.0	13	60	90°	7.1	7	15	100°	38	7.8	75	8.5	7.05
" 6	60	4	11.6	90	86°	10.6	7	15	96°	39	7.4	81	7.5	8.00
" 7	50	3	13	90	84°	10.6	6	14	96°	22	7.6	59	5.5	9.09
" 8	60	4.5	12.4	60	90°	7.1	6	13	100°	21	7.4	66	7.5	8.00
" 9	60	3.5	12.4	60	90°	7.1	5	10	100°	35	7.4	72	7	8.57
" 10	60	4.5	13.2	60	90°	7.1	6.5	13	100°	25	7.6	60	8.25	7.27
" 21	60	4.7	12.4	60	90°	7.1	6	15	102°	24	6.6	54	7.78	7.71
" 22	60	4.7	12	70	90°	8.4	6.5	14	100°	33	7	69	7.78	7.71
" 31	90	3.35	12.2	65	90°	7.7	6	12	96°	24	7	65	10.7	8.41
Apr. 3	90	.....	20	20	86°	2.1	5	10	96°	.....	.....	47	8.8	10.22
" 5	90	3.3	14	60	86°	7.1	7	14	86°	38	8	77	10.8	8.33
" 7	90	3-1	12.2	70	86°	8.3	6.5	12.6	96°	26	7	67	10.6	8.49
May 8	140	2.5	12.2	70	88°	8.3	6.5	14	98°	40	7.2	97	14.3	9.70
" 9	165	2.6	12.6	75	88°	8.8	7	15	98°	40	7.2	99	16.5	10.00

TABLE XLVII. —Analysis of Milk, Whey and Edam Cheese.

Date		Percentage composition		From 100 lbs. milk.		
		Solids	Fat	Lbs.	Solids	Fat
Feb. 7	Milk	13.65	4.9	100.00	13.65	4.90
	Whey	6.75	.41	86.82	5.86	.36
	Gr. cheese	59.10	34.48	13.18	7.79	4.54
Feb. 8	Milk	13.82	4.8	100 00	13.82	4.80
	Whey	7.11	.57	86.88	6.18	.50
	Gr. cheese	58.24	32.81	13.12	7.64	4.30
Feb. 9	Milk	13.69	5.0	100.00	13.69	5.00
	Whey	6.93	.5	86.84	5.92	.43
	Gr. cheese	58.31	34.70	13.16	7.77	4.57
Feb. 10	Milk	14.17	5.2	100.00	14.17	5.20
	Whey	7.30	.79	86.06	6.28	.68
	Gr. cheese	56.61	32.42	13.94	7.89	4.52
Feb. 12	Milk	.....	.....	.....	.....	.....
	Whey	.....	.....	.....	.....	.....
	Gr. cheese	.....	.....	.....	.....	.....
Feb. 14	Milk	13.65	4.7	100.00	13.65	4.70
	Whey	7.20	.58	85.96	6.18	.50
	Gr. cheese	52.91	29.77	14.10	7.47	4.20
Feb. 15	Milk	14.02	4.8	100.00	14.02	4.80
	Whey	7 28	.54	86.09	6.27	.46
	Gr. cheese	55.75	31.17	13.91	7.75	4.34
Feb. 19	Milk	14.00	4 9	100.00	14.00	4.90
	Whey	7.00	.59	85.98	6.02	.51
	Gr. cheese	56.94	31.39	14.02	7.98	4.39
Feb. 20.	Milk	14.10	5.1	100.00	14.10	5.10
	Whey	7.15	.72	86.00	6.15	.62
	Gr. cheese	56.86	32.00	14.00	7.95	4.48
Feb. 20	Milk	14.10	5.1	100.00	14.10	5.10
	Whey	7.35	.82	85.50	6.28	.70
	Gr. cheese	53.93	30.34	14.50	7.82	4.40
Feb. 28	Milk	13.24	4.7	100.00	13.24	4.70
	Whey	6.95	.50	86.83	6.02	.43
	Gr. cheese	54.73	32.36	13.17	7.22	4.27
March 3	Milk	13.93	4.4	100.00	13.93	4.40
	Whey	7.24	.45	86.53	6.26	.39
	Gr. cheese	56.96	29.81	13.47	7.67	4.01
March 5	Milk	13,99	5.	100.00	13.99	5.00
	Whey	7.48	.58	85.83	6.42	.50
	Gr. cheese	53,41	31.76	14.17	7.57	4.50
March 6	Milk	12.78	4.	100.00	12.78	4.00
	Whey	7.31	.51	87.50	6.40	.45
	Gr. cheese	51.07	28 40	12.50	6.38	3.55
March 7	Milk	10.84	3.	100.00	10.84	3.00
	Whey	6.36	.34	89.00	5.66	.30
	Gr. cheese	47.09	24.55	11.00	5.18	2.70
March 8	Milk	13.13	4.5	100.00	13.13	4.50
	Whey	6.98	.52	87.50	6.11	.46
	Gr. cheese	56.27	32.40	12.50	7.02	4.04
March 9	Milk	12.28	3.5	100.00	12.28	3.50
	Whey	7.30	.70	88.33	6.45	.62
	Gr. cheese	50.00	24.71	11.67	5.83	2.88
March 10	Milk	12.30	4.5	100.00	12.30	4.50
	Whey	7.20	.73	86.25	6.21	.63
	Gr. cheese	44.24	28.12	13.75	6.09	3.87
March 21	Milk	13.59	4.7	100.00	13.59	4.70
	Whey	7.53	1.0	87.03	6.55	.87
	Gr. cheese	54.24	29.56	12.97	7.04	3.83
March 22	Milk	13.24	4.7	100.00	13.24	4.70
	Whey	7.44	.88	87.03	6.48	.77
	Gr. cheese	54.76	29.82	12.97	6.76	3.93

TABLE XLVIII.—Analysis of Milk, Whey and Edam Cheese.

Date		Percentage Composition.						
		Solids	Water	Fat	Solids not fat	Ash	Protein	Lactose
March 31	Milk	12.30	87.70	3.35	8.95	.73	3.30	4.90
	Whey	7.04	92.96	.67	6.37	.42	.84	5.05
	Gr Cheese	51.31	48.69	23.21	28.10	3.02	21.49	3.83
Apr. 5	Milk	12.68	87.32	3.43	9.25	.70	3.57	4.91
	Whey	6.83	93.17	.44	6.39	.44	.96	5.05
	Gr Cheese	55.56	44.44	25.37	30.19	2.59	22.69	3.79
Apr. 7	Milk	12.32	87.68	3.15	9.17	.76	3.68	4.80
	Whey	6.87	93.13	.46	6.41	.36	.93	5.05
	Gr Cheese	53.20	46 80	23.30	29.90	3.68	24.24	2.92

Date		From 100 lbs. of Milk.							
		Pounds	Solids	Water	Fat	Solids not fat	Ash	Protein	Lactose
March 31	Milk	100.00	12.30	87.70	3.35	8.95	.73	3.30	4.90
	Whey	88.11	6.10	81.91	.59	5.61	.37	.74	4.45
	Gr Cheese	11.89	6.20	5.79	2.76	3.34	.36	2.56	.45
April 5	Milk	100.00	12.68	87.32	3.43	9.25	.70	3.57	4.91
	Whey	88.00	6.01	81.99	.39	5.63	.39	.85	4.45
	Gr Cheese	12.00	6.67	5.33	3.04	3.62	.31	2.72	.46
April 7	Milk	100.00	12.32	87.68	3.15	9.17	.76	3.68	4.80
	Whey	88.22	6.06	82.16	.41	5.65	.32	.82	4.46
	Gr Cheese	11.78	6.26	5,52	2.74	3.52	.44	2.86	.34

METHOD OF MANUFACTURING GOUDA CHEESE.

For a number of years there have been numerous inquiries as to the best method of manufacturing cheese in the home dairy. The answers to these inquiries have uniformly been a lengthy description of the cheddar process, which is not at all adapted to home work. By this process a whole day is required, even when a single cheese is made. What the isolated farmer needs is a short process which requires a small outlay only, for apparatus. After a careful study of the methods employed in the manufacture of the numerous foreign brands, the Gouda has been selected as the one best adapted for the home dairy. First, the milk is worked warm, fresh from the cow; second, it requires less than two hours to do the work; third, the cheese can be cured in a cellar or in any damp, cool place; fourth, it is a good keeper; fifth, it is nutritious and palatable.

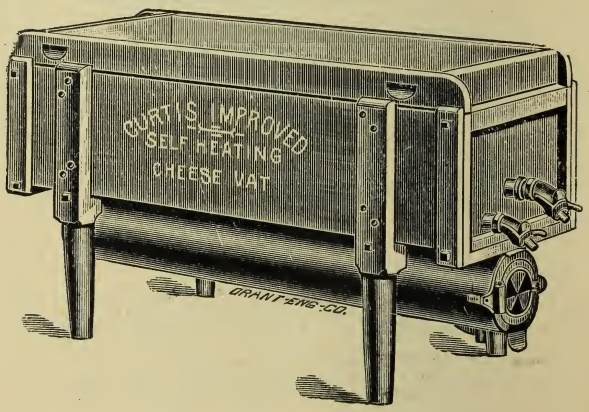


Fig. 6. Self Heating Cheese Vat.

Gouda cheese is largely manufactured in Southern Holland where climatic conditions are very different from those which exist in the northwest. We are subject to greater and more sudden changes in temperature and a drier atmosphere. It is therefore evident that the control of temperature and moisture must be provided for. In Holland the cheese is similar in form to the American cheddar, except that the upper and lower edges are rounded. They ordinarily weigh from eight to sixteen pounds. The cheese made in

the Minnesota Dairy School and in these experiments weighed from seven to eight pounds and are better adapted for family use.

Gouda is a sweet curd cheese made from whole milk fresh from the cow, preferably before it cools below 88 degrees. To prevent cooling it is better to strain at once into a wooden vat lined with tin or copper which prevents rapid cooling; or into a small self heating vat. If color is used one dram to 150 pounds of milk will give about the proper shade. The temperature of the milk, when the rennet is added, should be from 88 to 90 degrees. Enough rennet should be used to make the curd ready for the knife in fifteen to twenty minutes. This will require from seven to twelve ounces of rennet to 1000 pounds of milk, according to the strength of the rennet. To ascertain when it is ready to cut insert the finger in the milk at an angle of 45 degrees until the thumb touches the milk, gently raise the finger and if the curd breaks clean across it leaving but few or no flakes, it is ready. A little practice will soon teach one when the curd cuts to best advantage. It should not become so firm that it will cut hard by gathering in front of the knife or swaying off to one side, as this causes uneven cutting. Neither should it be cut when it is too soft, as this occasions great loss of curd in the whey; yet the general tendency of the curd should be toward softness. To insure even cooking, cut fine—about the size of peas. Stir gently for about five minutes, then apply more heat until the curd reaches 102 to 104 degrees F.; this should require from 20 to 30 minutes. The curd should be stirred during the whole process, and when ready for the mold it should be quite firm and make a squeaky noise when chewed.

FILLING THE GOUDA MOLDS.

Now let the whey run off or dip it out, then fill the mold at once by taking a double handful of curd and pressing it gently but firmly into the mold. Care should be taken not to allow the curd to drain too much before it is put into the mold, as it will then be too dry to pack readily. When the mold is full take the cheese out, turn it and replace it in the

mold, put on cover and put it under press for an hour. The pressure should be light at first.

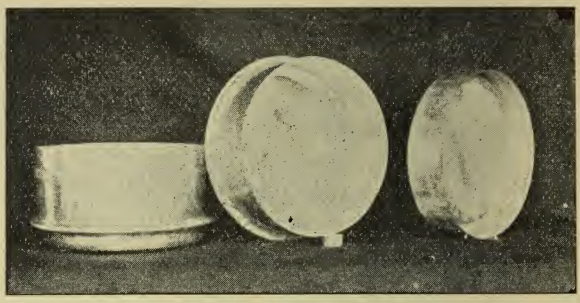


Fig. 7 Gouda Molds.

The press may be an oak stick four inches square, sixteen feet long, one end to rest under a slat nailed against the wall; place the cheese mold under the stick about three feet from the wall. On the other end suspend a pail or box containing cobble stones; during the first hour the pail should hang some two feet from the outer end of the stick. The cheese should then be taken out for dressing, which is done by taking a piece of cloth about six inches wide and long enough to go around the cheese. Dip cheese and cloth into whey or water at about 120 degrees Fahrenheit, wrap the cloth smoothly around the cheese, folding the edges carefully over the sides, put a linen cap on each side, replace in mold and again put it under the press; now move the vessel containing the stones or other weights toward the end of the stick, to increase the pressure. Leave it in press from eighteen to twenty-four hours at which time it will be ready for salting.

SALTING AND CURING GOUDA CHEESE.

This is done by rubbing the cheese all over with salt, once a day for six to ten days, according to temperature, moisture and desired keeping qualities. The cheese should be turned every day. Sometimes brine salting will bring better results. Make a brine as strong as possible, let the cheese float in it from five to eight days turning every day and sprinkling a little salt on top. When salted they should

be washed in warm water, wiped dry and placed on the shelf for curing. Be sure to rub and turn them at least once a day the first month, twice a week the second month, and once a week the third month. The curing room should be cool and rather damp. The temperature should not vary more than from 55 to 65 degrees.

If one has no vat for the milk, weigh it and put it fresh into a boiler or tub. When the milk is at the proper temperature add the rennet at the rate of three small tablets to 100 pounds of milk. Dissolve the tablets in a teacup of warm water (not hot), mix thoroughly in the milk by stirring carefully with an inverted dipper. Cut the curd very carefully with a wire broiler or toaster, such as is used in the kitchen. The wires should not be more than ¼ to ⅜ of an inch apart; pass the broiler through the curd slowly when it is quite soft. To cook the curd draw off about half the whey and warm to 100 degrees and pour into the vat, gently stir for ten or twelve minutes, then pour off the whey through a sieve or cloth strainer; quickly pour into the curd enough water, heated to 104 degrees, to cover it, stir gently until sufficiently cooked, which should take from fifteen to twenty minutes. If the curd seems to firm up too slowly, raise it to 105 or 106 degrees by adding more warm water. If you have no mold the cheese can be pressed in a sieve, steamer or four-quart measure. If you have no coarse linen use cotton cheese cloth or similar fabric. Scald the whey, and after cooling skim off the fat, which can be used for culinary purposes.

Only absolutely pure milk can be used in sweet curd work. If any cow is out of health, off her feed, feverish or excited, better throw her milk away or use it for making butter. If there is danger of the curd being tainted or gassy the whey should be let off at once and the curd cooked in water. When it has developed firmness the water should be drawn off and the curd thoroughly worked before putting into the mold.

TABLE No. XLIX.—Tabulated Statement of Process and Principal Conditions in the Manufacture of Gouda.

Date.	Lbs. of milk in vat.	Per cent fat in milk.	Amount of alkali necessary to neutralize acidity of Milk.	Rennet test for ripeness.	Temp. of milk when test was taken.	Amt. extract used per 1000 lbs. milk.	Time required until coagulation begins	Time required until ready for knife.	Temp. to which curd was heated.	Time required to cook the curd.	Amount of alkali necessary to neutralize acidity of whey.	Time from adding rennet to putting to press.	Weight of green cheese.	Lbs. of milk to 1 lb. cheese.
1894			c.c.	secs.			mins.	mins.		mins.	c.c	mins.		
Feb. 28	69	5.00	14.3	53	92°	.....	9.38	24	104°	77	10	128	8.5	8.1
March 12	100	4.50	12.4	70	90°	8.2	6	18	102°	45	7.4	76	12	8.33
" 13	100	4.20	12.6	60	90°	7.1	6	18	100°	44	7.4	77	14	7.14
" 14	100	4.90	13	60	90°	7.1	7	21	100°	39	7.2	80	14	7.14
" 15	100	5.00	13	60	90°	7.1	8	24	100°	39	7	85	14	7.14
" 16	100	.....	13	60	90°	7.1	6	18	102°	18	7.6	51	14	7.14
April 9	100	4.86	13	60	90°	7.1	6	18	98°	107	7	87	14.1	7.09
" 11	100	4.22	12.4	65	86°	7.7	6	19	98°	60	7	99	13.5	7.33
" 12	100	4.50	12.4	70	90°	8.5	6	18	98°	60	7.4	93	14.1	7.09

TABLE L.—Analyses of Milk, Whey and Gouda Cheese.

Date		Composition Solid	Fat	From 100 lbs. of milk Lbs.	Solids	Fat
Feb. 28	Milk	13.98	5.00	100.00	13.98	5.00
	Whey	7.16	.50	87.68	6.27	.44
	Green cheese	62.59	36.71	12.32	7.71	4.56
March 12	Milk	13.15	4.50	100	13.15	4.50
	Whey	7.03	.46	88	6.19	.40
	Green cheese	58.00	34.17	12	6.96	4.10
March 13	Milk	13.60	4.20	100	13.60	4.20
	Whey	7.23	.60	86	6.22	.52
	Green cheese	52.71	26.21	14	7.38	3.68
March 14	Milk	14.44	4.90	100	14.44	4.90
	Whey	7.20	.65	86	6.19	.56
	Green cheese	58.93	31.00	14	8.25	4.34
March 15	Milk	13.73	5.00	100	13.73	5.00
	Whey	7.27	.67	86	6.25	.58
	Green cheese	53.43	31.57	14	7.48	4.42

TABLE LI.—Amount of Solids Lost and Recovered in Making Gouda Cheese.

Date.	Per cent. solids in milk.	Pounds of green cheese from 100 lbs. milk.	Pounds of solids lost in whey from 100 lbs. milk.	Pounds of solids recovered in cheese from 100 lb. milk	Per cent. of solids in milk lost in whey.	Per cent. of solids in milk recovered in cheese.
March 13..	13.60	14.00	6.22	7.38	45.74	54.26
April 11.....	13.21	13.50	5.99	7.22	45.34	54.66
March 12..	13.15	12.00	6.19	6.96	47.07	52.93
April 12.....	13.69	14.10	6.16	7.53	45.00	55.00
April 9.....	13 80	14.10	6.19	7.61	44.86	55.14
March 14..	14.44	14.00	6.19	8.25	42.87	57.13
March 15..	13.73	14.00	6.25	7.48	45.52	54.48
Feb. 28.....	13.98	12.32	6.27	7.71	44.85	55.15

TABLE LII.—Amount of Fat Lost and Recovered in Making Gouda Cheese.

Date	Per cent fat in milk	Lbs. of gr. cheese from 100 lbs. of milk	Lbs. of fat lost in whey from 100 lbs. of milk	Lbs. of fat recovered in cheese from 100 lbs of milk	Per cent of fat in miik lost in whey	Per cent of fat in milk recovered in green cheese
March 13..	4.20	14.00	.52	3.68	12.38	87.62
April 11.....	4.22	13.50	.30	3.92	7.10	92.90
March 12..	4.50	12.00	.40	4.10	8.89	91.11
April 12.....	4.50	14.10	.51	3.99	11.33	88.67
April 9.....	4.86	14.10	.47	4.39	9.67	90.33
March 14..	4.90	14.00	.56	4.34	11.43	88.57
March 15..	5.00	14.00	.58	4.42	11.60	88.40
Feb. 28.....	5.00	12.32	.44	4.56	8.80	91.20

TABLE LIII.—Analyses of Milk, Whey and Gouda Cheese.

Date		Percentage Compositian. Solids....	Water ...	Fat.....	Solids not fat..	Ash	Protein.	Lactose.
April 9	Milk	13.80	86.20	4.86	8.94	.71	3.35	4.85
	Whey	7.21	92.79	.55	6.66	.41	.94	5.15
	Gr Cheese	53.97	46.03	31.13	22.84	2.55	18.01	3.04
April 11	Milk	13.21	86.79	4.22	8.99	.75	3.40	4.88
	Whey	6.93	93.07	.35	6.58	.42	.92	5.15
	Gr Cheese	53.48	46.52	29.04	24.44	2.88	19.25	3.18
April 12	Milk	13.69	86.31	4.50	9.19	.78	3.54	4.90
	Whey	7.17	92.83	.59	6.58	.40	.90	5.15
	Gr Cheese	53.41	46.59	28.29	25.16	3.12	19.64	3.40

Date		From 100 lbs. of Milk. Pounds.	Solids....	Water ..	Fat.....	Solids not fat..	Ash.....	Protein.	Lactose.
April 9	Milk	100.00	13.80	86.20	4.86	8.94	71	3.35	4.85
	Whey	85.90	6.19	79.71	.47	5.72	.35	.81	4.42
	Gr Cheese	14.10	7.61	6.49	4.39	3.22	.36	2.54	.43
April 11	Milk	100.00	13.21	86.79	4.22	8.99	.75	3.40	4.88
	Whey	86.50	5.99	80.51	.30	5.69	.36	.80	4.45
	Gr Cheese	13.50	7.22	6.28	3.92	3.30	.39	2.60	.43
April 12	Milk	100.00	13.69	86.31	4.50	9.19	.78	3.54	4.90
	Whey	85.90	6.16	79 74	.51	5.65	.34	.77	4.42
	Gr Cheese	14.10	7.53	6.57	3.99	3.54	.44	2.77	.48

TABLE LIV.—Tabulated Statement of Process and Principal Conditions in the Manufacture of Emmenthaler (Swiss Cheese.)

Date.	Lbs. of milk in vat.....	Per cent of fat in milk.....	Amount of alkali necessary to neutralize acidity of milk.....	Rennet test for ripeness.....	Temp. of milk when test was taken	Amount of extract used per 10,00 pounds of milk.....	Time required until coagulation begins	Time required until ready for breaking.....	Temp. to which curd was heated..	Time required to cook the curd.....	Per cent fat in whey.....	Time from adding rennet to putting to press.....	Weight of green cheese.....	Lbs. of milk to 1 lb. of cheese.....	Lbs. of cured cheese.....
1894			cc.	secs.		ozs.	mins.	mins.		mins.		mins.			
Jan. 16.....	370.	4.1	.....	70	90°	5.30	11	31	120°	55	1.1	106	39.3	9.41	31.6
" 17.....	330.7	4.2	.....	75	88°	6.50	9	29	110°	45	.7	118	37.	8.93	.....
" 20.....	327.6	3.5	.....	40	88°	2.10	9	22	112°	75	.5	122	32.3	10.14	30.9
" 22.....	374.2	4.0	15.3	99	90°	5.98	13	32	115°	70	.8	150	38.5	9.71	28.7
" 23.....	355.3	4.2	14.5	105	90°	5.50	15	35	115°	42	.9	138	38.1	9.32	27.3
*Feb. 2	187.	4.6	.....	120	90°	8.54	11	30	119°	57	.3	248	24.6	7.55	20.
" 6.....	369.5	4.9	14.	90	92°	7.09	10	24	115°	56	.5	264	41.	9.01	34.3
Mch. 24	248.	4.5	12.8	60	90°	4.03	10	30	120°	66	.8	133	30.	8.27	.....
" 27.....	300.	4.5	12.4	70	90°	3.85	12	36	120°	58	.9	127	34.	8.82	.....
" 29.....	224.	4.4	12.2	60	90°	3.50	11	33	120°	59	1.3	109	25.	9.	.....

*Curd cut with American knife.

The foregoing table includes the cheese made under the direction of Hon. John Luchsinger during the session of the Dairy School in January, those made by J. H. Hecker in February and W. P. Simpson in March. All the cheese were made of whole milk, except the one made the 20th of January which consisted of two-thirds whole milk and one-third skim.

The milk used during January and February was purchased from a creamery in the southern portion of the state and from dealers in the city, being mixed evening's and morning's milk which had been subjected to low temperature in shipping; while that worked in March was morning's milk. The mixed milks required 14cc to 15.3cc to neutralize the acid, while the fresh morning's milk required 12.2 to 12.8. In comparing the alkali test with the rennet test it will be observed that on the days when the milk required from 14 to 15.3cc alkali to neutralize the acid, the rennet test required from 90 to 105 seconds before coagulation commenced, and in March when the milk required from 12.2 to 12.8cc alkali, coagulation commenced in from 60 to 70 seconds. The milk worked on the 20th of January commenced to coagulate in nine minutes with only two ounces of rennet to 1000 pounds of milk and was ready for breaking in twenty-two minutes. That used on the 23rd of January took 15 minutes before commencing to coagulate and it was not ready for breaking until after the expiration of 35 minutes. With ordinarily sweet milk the time from adding the rennet until the curd is ready to break is 31 minutes. The temperature to which the curd was raised ranged from 110 to 120 degrees. The curd of January 17th was cooked at 110 degrees, and although kept under exactly the same conditions as the other cheese made the same month, it was ready for the market early in May. It was sold to a grocer and retailed readily at 18 cents; as soon as it was sold he called at the Station and offered 15 cents for all on hand. The cheese made on the 23rd of January was ripe in six months, while none of the others appear to be ripe at the close of the seventh month.

The cheese made from whole milk and the curd reduced

by a curd breaker shrunk in the process of curing on an average, 24.6 per cent; while that cut with an American curd knife shrunk 18.7 per cent. When the curd breaker was used to reduce the curd, it required, on an average 10.3 pounds of milk for one pound of cured cheese and when a knife was used a pound of cured cheese was made from 9.3 pounds of milk. The average loss of fat in the whey was .83 of one per cent. when the breaker was used and .30 with the curd knife. With whole milk and using the breaker, the cheese shrunk in curing 26.1 per cent; using the knife the shrinkage was 9.3 per cent.

The whey from the Swiss cheese made on the 16th of January was raised to 150 degrees F., the butter fat skimmed and two pounds of butter were made of inferior quality. On the 17th of January the whey was run through a No. 3 Alpha Separator, a good sour milk starter was added and the cream churned the day following, giving a yield of 2.1 pounds of fair butter, the flavor being much better than that made the day previous. On the 22nd there was drawn from the Swiss curd 322 pounds of whey to which was added 6.7 pounds butter milk and 7.6 pounds of cream testing 25 per cent. fat. It was then condensed and made 33 pounds Primost of the finest quality, which sold for 12½ and 15 cents per pound. The milk from which the cheese was made on the 23rd was frozen but otherwise was in good condition. It required 14.5cc alkali to neutralize the acid but the rennet test showed 105 seconds when coagulation commenced. After seven months this was the best cheese in the lot but hardly ready for consumption.

On the 2nd of February the American curd knife was used to note the effect, if any, upon the curd, loss of fat, flavor and texture; fat in whey .3 of one per cent. After seven months the cheese was tried and found dry and almost closed, the Swiss holes were few, small and lacked that lively glossy appearance characteristic of good Emmenthaler; it also lacked the proper flavor.

From the cheese made on the 6th of February, 300 pounds of whey were taken and run through a hand separator obtaining 9.3 pounds of cream which was churned, yield-

ing 3 pounds of unsalted butter. When six months old the cheese was in fine condition but was far from being ripe. Those made the 24th, 27th and 29th are to all appearance in fine condition and promise good results though not mature at this writing.

The whey of the 24th was separated, giving 9 pounds of cream, which was cooled to 45 degrees F., and after two hours raised to 65 degrees F., and three pounds of fresh buttermilk added. The following day it was churned at 62 degrees F., washed and worked at 56 degrees, and 1.9 pounds of butter obtained, which scored: flavor 40, grain 30, color 14, salt 8; total 92. It was cut five points on flavor, June standard, flavor good but not quick; one on color, being a point too high and two points short on salt.

On the 29th of March 192 pounds of whey were drawn, testing 1.1 per cent. fat. It was run through a hand separator, cooled to 50 degrees, in a couple of hours was raised to 65 degrees, twenty per cent. starter was added and set in a Boyd vat. The following day it was churned at 62 degrees F., washed and worked. Weight of butter 2.3 pounds. Flavor 38, grain 28, color 15, salt 10; total 91.

Whey butter as usually made is a very low grade of goods, selling about on a par with the grade generally termed "packing stock, poor," which sells for 10 cents when extra dairy butter sells at 20 cents. By running the whey through a separator and ripening the cream with good lactic ferment, the quality of the butter can be improved 25 to 50 per cent.

TABLE LV.—Analyses of Milk, Whey and Swiss Cheese.

Date.		Percentage Composition. Solids.	Water.	Fat.	Solids not fat.	Ash.	Protein	Lactose.
March 24...	Milk	13.35	86.65	4.51	8.84	.64	3.48	4.72
	Whey	7.13	92.87	1.01	6.12	.27	.90	4.97
	Gr. Cheese	58.57	41.43	29.93	28.60	3.34	22 13	2.90
March 27...	Milk	13.68	86.32	4.50	9.18	.63	3.63	4.90
	Whey	7.24	92.76	.83	6 41	.32	.92	5.10
	Gr. Cheese	64.09	35.91	33.21	30.85	3.06	24.82	3.32
March 29...	Milk	13.34	86.66	4.40	8.94	.80	3.32	4.87
	Whey	7.27	92.73	.88	6.39	.46	.86	5.07
	Gr. Cheese	61.64	38.40	32.40	29.44	3.48	22.88	3.24

Date.		From 100 lbs. of Milk. Lbs.	Solids	Water	Fat	Solids not fat	Ash	Protein	Lactose
March 24	Milk	100.00	13.35	86.65	4.51	8.84	.64	3.48	4.72
	Whey	87.90	6.27	81.64	.89	5.38	.24	.79	4.37
	Gr. Cheese	12.10	7.08	5.01	3.62	3.46	.40	2.68	.35
March 27	Milk	100.00	13.68	86.32	4.50	9.18	.63	3.63	4.90
	Whey	88.67	6.42	82.26	.74	5.68	.28	.82	4.52
	Gr. Cheese	11.33	7.26	4.06	3.76	3.50	.35	2.81	.38
March 29	Milk	100.00	13.34	86.66	4.40	8.94	.80	3.32	4.87
	Whey	88.84	6.46	82.38	.78	5.67	.41	.77	4.51
	Gr. Cheese	11.16	6.88	4.28	3.62	3.27	.39	2.55	.36

TABLE LVI.—Analyses of Milk, Whey and Emmenthaler Cheese.

Date		% Composition		From 100 lbs. of milk		
		Solids	Fat	Lbs.	Solids	Fat
Jan. 22	Milk	12.23	4.	100.	12.23	4.00
	Whey	7.07	.93	89.71	6.34	.82
	Gr. cheese	57.22	30.78	10.29	5.89	3.18
Jan. 23	Milk	10.98	4.2	100.	10.98	4.20
	Whey	7.37	.80	89.28	6.58	.72
	Gr. cheese	41.02	32.49	10.72	4.40	3.48

TABLE LVII.—Amount of Fat Lost and Recovered in Making Emmenthaler Cheese.

Date.	Per cent fat in milk	Lbs. of greencheese from 100 lbs. of milk	Lbs. of fat lost in whey from 100 lbs. of milk	Lbs. of fat recovered in cheese from 100 lbs. of milk	Per cent of fat in milk lost in whey	Per cent of fat in milk recovered in cheese
Jan. 22.....	4.00	10.29	.82	3.18	20.50	79.50
Jan. 23.....	4.20	10.72	.72	3.48	17.14	82.86
Mch. 29.....	4.40	11.16	.78	3.62	17.73	82.27
Mch. 27.....	4.50	11.33	.74	3.76	16.44	83.56
Mch. 24.....	4.51	12.10	.89	3.62	19.73	80.27

TABLE LVIII.—Amount of Solids Lost and Recovered in Making Emmenthaler Cheese.

Date	Per cent solids in milk	Lbs. of green cheese from 100 lbs. of milk	Lbs. of solids lost in whey from 100 lbs. of milk	Lbs. of solids recovered in cheese from 100 lbs. of milk	Per cent of solids in milk lost in whey	Per cent of solids in milk recovered in cheese
Jan. 22.....	12.23	10.29	6.34	5.89	51.84	48.16
Jan. 23.....	10.98	10.72	6.58	4.40	59.93	40.07
Mch. 29.....	13.34	11.16	6.46	6.88	48.43	51.57
Mch. 27.....	13.68	11.33	6.42	7.26	46.93	53.07
Mch. 24.....	13.35	12.10	6.27	7.08	46.97	53.63

University of Minnesota.

Agricultural Experiment Station.

BULLETIN No. 36.

CHEMICAL DIVISION.

NOVEMBER, 1894.

MISCELLANEOUS ANALYSES OF FEEDING STUFFS.

THE DIGESTIBILITY OF WHEAT.

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.

EAGLE JOB PRINT, DELANO, MINN.

University of Minnesota.

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☞ The Bulletins of this Station are mailed free to all residents of the State who make application for them.

ERRATA.

Page 134—Read: Blue joint hay, digestible protein 3.7 in place of 4.7.

Page 135—Read: Barley, digestible nitrogen free extract 56.6, in place of 5.66.

Page 138—Read: Nutrative ratio 6.4 in place of 6.5 in second paragraph 6th line.

Page 138—Read:

$$(2.08 + 3.31 + 8.10) \times 1860 = 25096$$
$$.76 \times 4225 = 3211$$
$$\text{Total Calories,} \quad 28307$$

(Minn. Bulletin No. 36, Nov. 1894).

MISCELLANEOUS ANALYSES OF FEEDING STUFFS.

HARRY SNYDER.

On account of the prolonged drouth of the past summer, the question of fodder, in some sections of the state, will require careful consideration. Many inquiries have been received from farmers regarding the comparative cost and composition of various foods. In many cases, samples of fodders and grains have been sent to the laboratory for chemical analyses. These analyses are published at this date, so that all who have occasion to either purchase or sell fodder during the coming winter may profit by the results.

The chemical analysis of a fodder, as ordinarily made, does not give all the information that a farmer desires, but for general comparative purposes the analysis gives much valuable information. The purchaser can judge for himself, as to the quality of the fodder or grain, whether it is musty or otherwise inferior. The analysis tells, practically, what the food contains, and by means of simple calculations, as will be explained later, the comparative amounts of muscle forming, and heat producing bodies which a given sum of money will purchase, can easily and readily be determined. Hence the analysis may serve as a guide to show which food will be the most economical to purchase or sell.

The important compounds present in fodders and food stuffs have been discussed in previous bulletins of this station. A few additional facts, however, about the comparative food values of the various compounds are given so as to aid in using the figures.

The analyses recorded in this bulletin are from samples of fodders grown under the conditions of climate and soil of this state; hence the results are better adopted to our con-

ditions, than average analyses of materials grown elsewhere.

EXPLANATION OF TERMS USED.

Water.—In all food stuffs, even those which have been thoroughly sun and air dried, there is an appreciable amount of water present. Substances like meal and flour which appear perfectly dry to the "feel" are not free from water. In the tables of analyses, the figures for water represent the amount which is present in every hundred pounds of the material. The last traces of water are removed by drying the substance in an oven at a temperature of 212 degrees Fahrenheit, when all of the water in the material is converted into steam and escapes.

The dry substance is what is left after all of the water has been removed from any material. Frequently the results of the analyses are expressed on the dry substance or water free material, as it is called. In this bulletin all of the results are given as they are present in the original material, or as ordinarily used, unless otherwise stated.

The Ash is what is left after the dry substance is burned. It is sometimes called the mineral or inorganic part. The ash is important inasmuch as it furnishes the main portion of the necessary materials for bone growth. Too much ash especially when it is rich in silica (sand), or of strong alkalies, as in the Russian thistle, is objectionable. The ashes from all grains are usually the richest in phosphates, and hence the most valuable for bone growth. In nearly all mature agricultural products there is less than ten per cent. ash. There is generally a sufficient amount of ash in all food products for bone growth.

The organic matter is that portion which is converted into smoke and volatile products when the dry matter is burned; hence the organic matter is readily found by subtracting the ash from the dry matter.

From the feeder's point of view the organic matter is divided into two large classes of compounds: (1) The non-nitrogenous compounds, and (2) the nitrogenous compounds. This division is made according to the presence or absence of the element nitrogen. Starch and sugar contain *no*

nitrogen, hence they are *non*-nitrogenous compounds, while albumen, the white of the egg, contains nitrogen, and hence is a nitrogenous compound.

The non-nitrogenous compounds include cellulose (mainly woody material), starch, sugar, fats, and the jellies which are known as pectose substances. In some fodders, in addition to these, there is a small amount of non-nitrogenous materials, like lignin, and the pentoses, which possess no food value. The non-nitrogenous compounds make up by far the larger portion of the dry matter of a fodder. There is from four to ten times more of the non-nitrogenous compounds in any ordinary food, than introgenous compounds. There is usually a sufficient amount of non-nitrogenous material in all foods, but the nitrogenous compounds are liable to be too deficient.

The fats and other bodies soluble in ether, known as the *ether extract*, are very concentrated forms of non-nitrogenous compounds. In the grains and milled products, the ether extract is nearly pure fat while in the grasses and hays it is from 50 to 65 per cent. pure. All fats contain about one half more carbon, the charcoal element, than is found in starch or sugar. Hence when fats are digested and undergo oxidation, and combustion within the body, they produce over twice as much heat as starch or sugar. The fat in the food has more to do with producing heat in the body, and but little to do, directly, with furnishing fat for the production of milk. In fact any good cow will give much more fat in her milk for a given period than there is fat in her food. A certain amount of fat in a food is essential, too large a a quantity when not associated with a sufficient amount of protein is objectionable.

The fiber constitutes the frame work of the plant, and is composed mainly of cellulose (woody material). The fiber is not entirely indigestible; in many foods it is about half digestible. Ordinary amounts of fiber, when associated with a sufficient amount of digestible materials is unobjectionable. The fiber and ash, in the foods as ordinarily used, ought not to exceed forty-five per cent. of the total nutrients because they represent too much inert material in a fodder.

Nitrogen free extract. In the analysis, the starch, sugar and jelly (pectose) substances are all classed together under the head of nitrogen free extract. The compound word nitrogen-free, means free from nitrogen. The bodies are all easily soluble in dilute acids and alkaline solutions. The term nitrogen-free extract, when applied to the fodder is a very indefinite one, but when only the digestible and valuable part of the nitrogen-free extract is considered, and not the inidgestible part, which possesses no value, the term becomes much more definite.

The Nitrogenous Compounds. The characteristic building material of these compounds is the element nitrogen. The nitrogenous compounds are, by far, the most expensive and the most important materials found in food stuffs. Unfortunately the terms employed to designate these bodies are somewhat confused. By many, the terms nitrogenous compounds, proteids and albuminoids are used synonymously. To the chemist these terms all have different meanings. *Crude* protein or total nitrogenous compounds is the term which includes and designates *all* of the nitrogenous bodies. The term protein represents only a *single* class of the total nitrogenous compounds. The crude protein or total nitrogenous compounds, includes, besides protein, amides, and alkaloids, bodies which possess little or no food value.

Protein is the largest and most important class of the nitrogenous compounds. The proteids are the materials out of which the muscles are formed, they enter into the compositon of the tissue of the nervous system, the ligaments, bones, hoofs, hair, and all of the vital fluids. The protein compounds supply the waste materials, and keep the complicated machinery of the body in repair. A certain amount of protein in the food is absolutely necessary to repair the waste of the body, and this necessary protein must be supplied before growth or the production of meat or milk can take place.

When an animal is supplied with all the digestible protein necessary to maintain the body, the excess is either stored up in the body, or used for producing fat in the milk.

Hence the necessity for keeping up a good supply of protein in the food. In fact, the chief benefit which is derived from the food consumed comes from the small amount which is in excess of that required for maintenance

In the tables, the nitrogenous material in the form of true protein is indicated in the column headed: "Per cent. of total nitrogen in the form of true protein."

The indigestible part of fodders. In all fodders and grains there is a certain amount of each of the food nutrients which is indigestible and can not be counted upon for food purposes. The amounts of the various indigestible nutrients in fodders have been determined by a number of American Experiment Stations.

In the tables the composition of every hundred pounds of fodder as ordinarily used, is given. On the same line under the head of parts digestible, is given the pounds of each digestible nutrient in the hundred pounds of fodder. Under the head of composition is given what is in the fodder, and under parts digestible, is given the amount which can be counted upon for actual food purposes. The results under parts digestible are calculated from the average results of American Digestion Co-efficients, and from the composition of the materials as here reported. The digestible nutrients of the grains and milled products are calculated mainly from our own results, published in Bulletin No. 26, and from experiments conducted for this purpose. In some cases where the digestibility of the food had not been determined, the digestion coefficieuts of other foods of the same class, and having about the same composition, were used.

In the table of analyses, the composition of all of the field cured crops show a less amount of hydroscopic moisture than is usually given for these crops or is present in crops grown in a climate where the atmosphere is more moist. This difference is easily accounted for by the fact that the atmosphere of this state is usually very dry, hence when the crops are air dried, they contain a correspondingly less amount of moisture.

AVERAGES OF MINNESOTA ANALYSES.

TABLE LIX. —Field Cured Crops.

		Composition of 100 lbs. of Fodder						Parts Digestible					Percent of total nitrogen as protein
	No. of samples	Water	Ash	Ether extract	Crude protein	Nitrogen-free extract	Fiber	Dry matter	Ether extract	Crude protein	Nitrogen free extract	Fiber	
Clover hay, red	6	12.25	6.78	2.97	12.67	41.08	24.05	52.5	1.5	7.6	28.0	12.0	85
Pea hay	5	12.50	8.95	2.75	12.37	36.29	27.13	52.5	1.4	7.4	25.1	12.7	84
Vetch	1	14.00	7.10	2.22	12.69	46.87	17.12	51.6	1.3	7.2	30.5	8.8	75
Timothy hay	4	12.32	5.11	2.38	6.07	43.50	30.62	50.8	1.3	3.4	27.2	16.2	82
Blue grass hay	4	14.00	6.92	3.91	8.45	37.52	29.20	50.0	2.2	4.6	23.6	16.4	85
Millet hay	1	12.00	8.95	1.50	6.52	41.03	31.00	55.2	1.0	3.9	27.5	21.	81
Mixed prairie hay	4	15.90	6.70	2.40	6.02	41.58	27.40	48.7	1.2	3.4	26.5	15.	85
Upland prairie hay	4	12.50	6.25	2.80	5.91	46.22	26.32	50.5	1.4	3.5	27.7	14.1	85
Blue joint hay	4	15.14	6.31	2.40	7.44	38.41	30.30	46.8	1.2	4.7	22.5	16.4	87
Sedge grass	1	10.16	7.66	2.00	5.94	44.12	30.12	50.2	1.1	3.4	26.4	18.9	80
Oat hay	2	15.00	6.87	3.25	8.75	38.01	28.12	51.8	1.3	5.7	23.9	17.4	80
Corn fodder	10	15.00	4.25	2.93	6.46	50.11	21.25	57.8	2.2	3.9	37.1	14.1	85
Wheat straw	3	7.41	9.22	.97	3.25	40.88	38.27	42.3	.4	1 0	16.4	21.6	71
Oat straw	3	8.36	9.00	1.40	4.06	38.07	41.11	45.8	.5	1.5	20.4	23.	70
Barley straw	3	10.40	9.11	.95	3.45	35.43	40.66	44.7	.4	1.0	19.1	21.5	75
Clover straw	2	13.50	7.80	1.57	8.63	33.10	35.40						

Green Crops and Ensilage.

Rape, whole plant	6	86.00	1.06	.25	2.09	8.89	1.71	9.8	.2	1.5	7.0	1.1	61
Rape, leaves	1	88.00	1.00	.38	2.04	7.50	1.08	8.6	.2	1.5	6.2	.6	75
Pasture, blue grass	2	85.00	1.75	.70	3.00	6.30	3.25	1.03	.9	1.9	4.5	2.4	70
Green clover	4	86.00	1.48	.75	3.36	6.54	1.87	9.3	.5	2.3	5.2	1.0	67
Ensilage, corn	12	74.00	1.40	.80	1.95	14.72	6.28	17.2	.6	1.2	11.3	3.7	82
Sugar beets	4	85.00	.85	.10	1.75	11.80	.50	14.1	1.1.	1.5	11.8	.5	60
Mangles	2	86.00	1.25	.25	1.95	9.45	1.10	10.6		1.5	8.5	.5	55

Grains.

Barley	6	11.78	3.32	2.70	11.20	65.88	5.12	70.6	1.8	9.1	5.66	2.4	94
Corn	7	11.00	1.50	3.88	10.25	71.72	2.25	80.1	3.1	9.2	67.4	1.1	95
Millet seed	6	12.50	3.82	3.89	10.61	61.11	8.07	70.0	2,9	9.0	48.5	5.6	.....
Oats	5	9.00	3.62	4.88	10.70	65.05	6.75	65.5	3,9	9.2	49.4	1.6	94
Peas	4	9.84	3.40	1.03	22.00	58.00	5.73	80.2	.5	19.4	55.1	4.5	96
Rye	2	11 00	2.10	2.01	12.75	70.04	2.10	72.9	1.5	10.5	58.	1.3	92
Wheat	25	11.00	1.92	2.05	13.75	69.03	2.25	73.	1.5	11.0	57.3	1.3	97
"Goose" wheat	1	10.85	1.81	1.77	16.41	66.60	2.50	72.	1.4	13.1	55.3	1.5	95
Flax seed	2	5.60	3.78	3.95	25.31	18.41	7.40	.....	.....	.....	.....	.....	.....

AVERAGES OF MINNESOTA ANALYSES (*Continued*).

Milled Products.

		Composition of 100 lbs. of Material.						Parts Digestible.					
	No. of samples.	Water.	Ash.	Ether extract	Crude protein	Nitrogen free extract.	Fiber.	Dry matter.	Ether extract	Crude protein	Nitrogen free extract.	Fiber	Percent total nitrogen as protein.
Corn meal	6	12.00	1 50	3.8	10.00	71.70	1.00	79.2	2.8	9.00	66.4	1.00	96.
Corn cobs	3	10.75	1.20	.44	1.43	54.03	32.15	53.8	.2	.2	32.0	20.00	80.
Cotton seed meal	3	8.14	7.95	11.20	44.38	22.71	5.61	65.0	10.0	32.00	16.0	4.2	91.
Gluten meal	3	10.00	.75	7.6	28.2	52.1	1.35	78.3	6.7	24.5	46.4	.6	92.
Germ meal	2	7.00	1.25	6.47	14.0	67.3	4.25	72.5	6.1	12.3	50.0	2.4	93.
Linseed meal (o. p.)	4	10.00	5.50	8.20	31.00	36.80	8.5	71.1	7.3	27.6	28.7	4.8	92.
Oat feed	2	10.00	4.2	6.2	15.00	57.1	7.5	56.0	3.7	11.1	37.0	3.1	92.
Wheat bran	12	10.50	6.01	4.95	15.65	52.04	10.85	60.0	3.6	12.5	38.5	3.6	96.
Wheat shorts	15	10.50	3.25	3.01	13.25	64.47	5.52	67.0	2.3	10.	54.4	1.5	98.
Wheat germ	8	10,50	2.75	3.50	16.25	64.75	2.25	70.	2.4	13.8	58.3	1.5	97.
Wheat flour	15	10.50	.50	.55	11.25	77.2	.....	85.	.4	10.6	73.3	.....	98.
Wheat flour, "Red Dog"	8	10.00	2.25	2.75	15.75	67.65	1.60	78.	2.0	13.5	60.1	1.2	97.
Wheat screenings	4	10.00	2.20	2.75	13.80	67.65	3.60						
Cockle bran	3	11.00	3.3	2.5	10.6	63.5	9.2						

The term *nutritive ratio* is frequently made use of in connection with feeding stuffs. The nutritive ratio is the ratio which exists between the digestible protein and the digestible non-nitrogenous compounds. A nutritive ratio of 1 to 6.7 means that for every one pound of digestible crude protein there are 6.7 parts of digestible non-nitrogenous compounds. A wide ration means a larger amount of non-nitrogenous compounds, a narrow ration a comparatively less amount.

To calculate the nutritive ratio first determine the pounds of digestible protein in the food used. Then calculate the pounds of digestible fiber and nitrogen-free extract. Multiply the pounds of digestible fat by 2.5, because the fat produces so much more heat and is considered 2.5 times more concentrated than the nitrogen-free extract compounds. Add the digestible fiber, nitrogen-free extract, and corrected fat together, and divide the sum by the digestible protein, the result is the nutritive ratio.

In case a cow consumes 18 pounds of blue grass hay and ten pounds of bran per day the digestible nutrients and nutritive ratio are found as follows: From the table take the number of pounds of each digestible nutrient in a *hundred pounds* of the feed used Put the decimal point two places to the left so as to represent the amounts in *one* pound. Multiply the pounds of fodder used, by the amount of each separate digestible nutrient in one pound of that fodder.

The digestible nutrients in every hundred pounds of the blue grass hay and wheat bran used are:

	Protein.	*Ether Extract.*	*Fiber.*	*Nitrogen-free Extract.*
Blue grass hay	4.6	2.2	16.4	23.6
Wheat bran	12.5	3.6	3.6	38.5

The digestible nutrients in *one* pound would be a hundredth part of each amount above. In eighteen pounds of blue grass hay, there are the following amounts of each digestible nutrient: Crude protein 18 x .046 = .83 lbs.; fiber .164 x 18 = 2.95 lbs.; nitrogen-free extract 18 x 236 = 4.25 lbs., ether extract 18 x .022 = .4 lbs. In ten pounds of bran the digestible nutrients are: Protein 10 x .125 = 1.25

lbs., fiber 10 x .036 = .36 lbs., nitrogen-free extract 10 x .385 = 3.85 lbs., ether extract 10 x .036 = .36 lbs.

Tabulating the total pounds of each nutrient in both hay and bran we have:

	Protein	*Fiber*	*Nitrogen-free Extract*	*Ether Extract*	*Corrected Ether Extract.*
18 lbs. hay	.83	2.95	4.25	.40	.76 x 2½ = 1.90
10 lbs. bran	1.25	.36	3.85	.36	
Total nutrients	2.08	3.31	8.10	.76	1.90

Adding the digestible fiber, nitrogen-free extract and correct fat togetner, it gives 13.31 pounds of digestible non-nitrogenous compounds. 3.31 + 8.10 + 1.90 = 13.31. Dividing this number, which is the total digestible non-nitrogenous compounds, by the digestible protein, it gives 6.4. 13.31 ÷ 2.08 = 6.4. The nutritive ratio is 1 to 6.5. There is one part of the digestible protein to 6.4 parts of digestible non-nitrogenous compounds.

Heat produced by foods. When the food is digested it produces a definite amount of heat and muscular energy, which can be measured by the work that it is capable of doing. The heat produced is measured in calories. A calorie is the amount of heat required to raise the temperature of a kilogram of water from 0 to 1 degree Centigrade, or 2.2 lbs. of water 1.8 degrees Fahrenheit. One pound of digestible protein yields 1860 calories, a pound of digestible fiber or nitrogen-free extract compounds yields the same amount. One pound of digestible fat yields 4225 calories. The heat units, measured in calories, produced by the previous ration are found by adding the digestible protein, fiber, and nitrogen-free extract and multiplying the sum by the factor 1860. Then multiply the digestible fat by the factor; 4525, and add the two results.

(2.08 x 3.31 x 8.10) x 1860 =		25096
1.90 x 4225	=	8027
Total calories		33123

The amount of heat produced by various foods is an important factor, especially when the climate is very severe;

then a larger amount of heat will be required by the body. This heat must be supplied by the food.

NUTRIENTS AND HEAT UNITS BOUGHT FOR A DOLLAR.

The amount of digestible nutrients and heat units which can be purchased for a given sum of money, is the most important point to take into consideration in economic feeding. The prices of grain and milled products are not always in proportion to their actual values. A dollar expended in one food will frequently buy more digestible nutrients and heat units than when expended in other foods.

In the table LX. are given the pounds of digestible nutrients and of heat units which can be purchased for one dollar, when the prices are as stated.

In the table it will be seen that when corn is fifty cents per bushel or corn meal is eighteen dollars per ton, one dollar will buy more digestible protein and other nutrients in the form of bran or shorts at fifteen and sixteen dollars per ton. When the corn meal is the same price per ton, twelve dollars, the dollar would be as wisely expended in corn meal as in shorts.

When barley is selling at forty-eight cents per bushel, it will pay well to sell some of the barley, and even buy wheat at fifty cents per bushel, or corn meal at eighteen dollars per ton. Again, when oats are selling at twenty-eight or thirty cents per bushel, it will pay to sell part of the oats and buy some cheaper grain or mixture.

When timothy hay is selling for eight dollars per ton, and clover hay at ten dollars per ton it will be cheaper to to sell the timothy and keep the clover or buy the clover in preference to the timothy.

When the differences are small between two foods, as to the amounts of digestible nutrients which can be purchased for one dollar, the farmer can use his own judgment, and purchase or sell as best suits his purpose. The table is to be used more as a guide. When the differences are large, and much in favor of one food at a certain price, it will be econo

my to purchase the food which will give the larger amount of digestible protein and other nutrients for a given sum of money.

TABLE LX.—Digestible Nutrients and Heat Units Bought for One Dollar.

Kind of fodder or grain.	Price per ton	Pounds Digestible.				Heat units
		Dry matter	Protein	Ether extract mainly fat	Nitrogen free extract and fiber	
Bran	$12.00	100	20	6	71	194.610
Bran	15.00	80	16	5	56	155.045
Corn meal	18.00	87	10	3	74	168.915
Corn meal	12.00	132	15	5	112	257.345
Corn and cob meal	15.00	100	10	3	86	191.235
Corn shelled, 50c bu		87	9	3	75	168.915
Wheat shorts	12.00	111	17	4	90	216.029
Wheat shorts	16.00	85	12	3	70	165.195
Oats, 30c per bu		72	10	4	56	139.760
Linseed meal	28.00	51	19	5	24	91.105
Linseed meal	24.00	59	23	6	28	120.210
Barley, 48c per bu		71	9	2	59	134.930
Peas, $1 per bu		48	12	3	36	101.955
Peas, 70c per bu		68	16	4	49	137.900
Gluten meal	22.00	71	22	6	43	146.250
Cotton sead meal	28.00	47	23	7	14	97.395
Wheat, 50c per bu		87	14	2	70	155.987
Timothy hay	8.00	127	9	3	108	230.295
Prairie hay	6.00	163	11	4	138	294.040
Clover hay	10.00	105	15	3	82	193.095
Millet hay	8.00	138	10	3	121	256.236
Rye, 45c per bu		88	13	2	72	166.550

In case the grains or fodders are at different prices from those stated in the table, either add or subtract the proportional amount of each nutrient, or calculate from the tables the amounts purchasable for one dollar. In order to do this, first find how many pounds of fodder or grain can be purchased for the dollar, multiply this amount by the per cent. of digestible nutrients contained in the fodder, which

will give the pounds of digestible nutrients that can be purchased for one dollar.

In case wheat bran is eighteen dollars per ton, the dollar will purchase 111 pounds of bran, each pound of bran contains 1.25 pounds digestible protein, hence 111 pounds bran contain about 14 lbs. of digestible protein. In like manner the other digestible nutrients are determined. In the table LX. the value of the manure is not taken into consideration. Inasmuch as all grains are sold by weight instead of the measured bushel, the legal weight per bushel, of the various grains, as approved by the Minnesota Legislature, April 17, 1893, are given.

	Pounds per bushel.		Pounds per bushel.
Barley	48.	Millet Seed	48.
Buckwheat	50.	Oats	32.
Corn, shelled	56.	Peas	60.
Corn on cob	70.	Potatoes	60.
Clover seed	60.	Rye	56.
		Wheat	60.

In the purchasing of foods the preference should be given to those foods which contain the largest amount of digestible protein, because the protein is, by far the most expensive and important nutrient in foods. In case the difference in digestible protein is small, the one having the largest amount of digestible non-nitrogenous compounds should be purchased. When oats are thirty cents, and corn is fifty cents per bushel, a dollar will purchase nine pounds digestible protein in the form of corn, and ten pounds in the form of oats, but in the corn there is nearly twenty pounds more of starch, etc., than in the oats, which more than makes up for the pound less protein in the corn.

When linseed meal is twenty-eight dollars per ton, and and corn fifty cents per bushel, a dollar will buy ninteen pounds of digestible protein, and twenty-four pounds of digestible carbohydrates as linseed meal, and nine ponnds of protein and seventy-five pounds of carbohydrates, as corn. Ten pounds of protein are in favor of the linseed meal, while fifty-one pounds of carbohydrates are in favor of the corn. The additional fat in linseed meal, will bring the fifty-

one pounds of carbohydrates in the corn down to forty-six. The question is: which is worth more, nine pounds of protein, or forty-five pounds of car bohydrates? This depends upon what the corn or linseed meal is to be mixed with or fed to. When the linseed meal is selling at the lower figure, twenty-four dollars per ton, the nutrients are in favor of the linseed meal.

When corn meal is selling at eighteen dollars per ton, and corn and cob meal at fifteen dollars per ton, the corn and cob meal will be as cheap as the corn meal, provided that only those cobs are present which actually belong to the corn. The same amount of digestible protein will be purchased in each case, ten pounds, but in the corn and cob meal there are thirteen pounds more of the digestible carbohydrates. In purchasing corn and cob meal there is some risk of getting more cobs than belong in the meal, which greatly reduces the value. When there is only two dollars per ton difference in the selling price of the two, it will be cheaper to purchase the corn meal, because the manure will be worth more, and the cost of hauling will be less on the more concentrated food.

When you are doing your own grinding it will be cheaper to feed the corn, as corn and cob meal, when the corn is selling at fifty cents per bushel, than to sell the corn and buy corn meal at eighteen dollars per ton. Ten bushels of shelled corn corn will weigh 560 pounds, and with the cobs it will weight 700 pounds. The 560 pounds of corn, and the 140 pounds of cobs will contain the following amounts of digestible nutrients:

	Dry Matter.	*Protein.*	*Fat.*	*Fiber.*	*Nitrogen free extract.*
Corn.....	448	51	17	6.1	375
Cobs.....	75	.3	.3	28.0	45

The corn cobs have added seventy-five pounds of digestible dry matter composed almost entirely of fiber, and nitrogen-free extract compounds.

When cotten seed meal and linseed meal are selling at the same price, there is but little difference between the feeding value of the two. Gluten meal at twenty-two dollars per ton compares very favorably with linseed meal at twenty-

four dollars per ton. There is a pound more digestible protein in the linseed meal, but in the gluten meal there are fifteen pounds more of digestible carbohydrates, which more than make up for the pound less of protein.

Gluten meal is not as constant in its composition as it should be; quite frequently it is mixed with the germ meal, which is a valuable food, but not so valuable as the gluten meal. Hence in purchasing gluten meal, as well as some of the other mill products, it would be wise to send a sample to the Experiment Station to see if it is all right.

FACTORS WHICH INFLUENCE THE COMPOSITION OF CROPS.

The factors which influence the composition and value of fodders are: (1) Stage of growth at which a fodder is harvested. (2) Effects of climate and season. (3) The time required for maturing the crop. (4) The protection which the crop is given after harvesting. (5) Quality of the seeds sown. (6) Quality and condition of soil.

The stage of growth at which a fodder is cut, has much to do with its composition. In the case of timothy, cut at different stages of growth, there is a marked difference in composition. In the year 1891 samples of timothy were cut at three different stages of growth and analyzed. The composition of the timothy for each period on a uniform basis of ten per cent. water, was:

	Before Bloom.	*In Early Bloom.*	*Ripe.*
Ash	7.09 per ct.	6.32 per ct.	5.45 per ct.
Ether Extract	2.87 "	2.51 "	2.22 "
Crude Protein	9.84 "	7.62 "	6.42 "
Crude Fiber	28.17 "	31.12 "	32.52 "
Nitrogen Free Extract,	42.02 "	42.43 "	43.39 "

The largest amount of dry matter is obtained when the timothy is ripe, while the largest amount of protein is obtained from early to late bloom. The same is true with clover and nearly all agricultural crops. The first stages of growth are devoted mainly to the formation of nitrogenous

compounds, while the materials which are added to the crop in the last stages of growth are mainly non-nitrogenous compounds. Early cutting gives a smaller amount of a more concentrated fodder. While late cutting gives a larger quantity, and a less concentrated fodder.

Effects of Seasons. When the growing season is favorably prolonged, larger amounts of starch and other non-nitrogenous compounds are stored up in the plant because the conditions are more favorable for this kind of growth. It seems that plants devote their energy, at first, more to the formation of the nitrogenous compounds, than to the development of the non-nitrogenous compounds.

In early and late varieties of any kind of food products, the early maturing varieties will invariably show the larger proportion of protein, while the late varieties will show the larger amount of starch and other carbohydrates. Hence in aiming to secure as early ripening crops as possible by means of selection of seeds and otherwise forcing tbe growth, there is no loss of food value with the early maturing crops, but if anything, there is a gain by having a larger proportion of nitrogenous compounds on account ot the plant being forced in that direction.

Even the potato, which is strictly a starchy food, is influenced by this condition. Early varieeies of potatoes contain more protein than later varieties on account of more starch being formed in the later varieties during their prolonged growth. In early and late maturing crops of the same variety, the difference in composition falls on the protein, which is in favor of the early maturing varieties, and on the starch, which is in favor of the late maturing varieties. The early maturing varieties are placed at a little disadvantage on account of a shorter growing period and a shorter time to procure their mineral food from the soil. All early maturing crops should be favored with thorough cultivation and manuring in order to make up for this shorter period of growth. Early maturing varieties require that the soil should be in its best condition.

The effect of heavy showers and prolonged rains on hay after it is cut, and when it is in stacks which are uncovered

and unprotected, is quite noticeable. In the season of 1891, which was a very rainy one, a sample of timothy weighing twenty-five pounds, was exposed to one heavy shower and three heavy dew falls. The sample was exposed in all five days and at the close weighed 21.5 pounds. The timothy was spread on a canvas cloth over a wire screen and covered with a wire screen, so as to prevent any of the hay from blowing away. The rain removed twelve per cent. of the best part of the dry matter of the hay. The sample was in early bloom when cut.

The per cent. loss of each nutrient was as follows:

Ash	17.26
Ether Extract	7.47
Crude Protein	7.69
Fiber	.20
Nitrogen-free extract	25.78

In actual hay making the losses would have been even larger, because some of the hay would have been lost mechanically.

THE DIGESTIBILITY OF WHEAT.

HARRY SNYDER.

The frequent low price of wheat and the high price of corn has created much interest in regard to the use of wheat as an animal food. The usual high price of wheat has prevented its extensive use as an animal food, and hence its digestibility has never been determined.

The digestibility of the wheat was determined mainly to observe the difference in digestibility between the whole grain and the cracked grain, and also to learn how the digestibility of wheat compares with that of other grains.

The wheat was fed to young pigs in two ways. In one case, whole wheat and coarsely ground (cracked) corn was fed, half and half by weight; in the other case, cracked wheat and corn was fed. The ration was the same in each case, except as to the difference in the way in which the wheat was fed. The results were duplicated, and those for the whole wheat were duplicated on different animals.

TABLE LXI.—Digestibility of Wheat, Whole and Cracked.

	Per cent. Digestible.	
	Whole Wheat.	Cracked Wheat.
Dry matter	72.	82.
Ash	44.	50.
Ether extract (fat)	60.	70.
Protein (gluten)	70.	80.
Fiber	30.	60.
Nitrogen-free extract	74.	83.

The results show a diffence of ten per cent. digestibility in favor of the cracked wheat. Had the wheat formed more

than half of the ration, the difference in digestibility would have undoubtedly been even greater.

When the wheat was fed whole, the loss consisted mainly of undigested kernels. These grains, when recovered from the dry manure, showed but little of the effects of the digestive organs. They were coated with a covering of mucus material, and when this coat was removed by washing with distilled water, the recovered wheat grain had practically the same composition as when fed.

TABLE LXII.—Composition of Whole Wheat as Fed and the Whole Wheat in the Manure.

	Whole Wheat as fed.	The whole wheat in manure.
Water	10.95 per cent	12.42 per cent
Ash	2.20 "	2.14 "
Ether extract (fat)	2.17 "	2.10 "
Protein (gluten)	14.18 "	13.75 "
Fiber	2.83 "	2.70 "
Nitrogen-free extract	67.67 "	66.89 "
Total	100.	100

The only noticeable difference is about two and one-half per cent. more water in the wheat recovered from the manure. When the results are compared on the basis of the dry matter, the difference in composition between the two samples is very slight.

The digestibility of cracked wheat compares very favorably with other grains. It does not appear to be quite as digestible as corn, but the dry matter is more digestible than that of barley, shorts or bran. For comparison the digestibility of a few other grains and products, as determined at this station, is given.

TABLE XLIII.—Digestion Co-Efficients of Wheat and other Grains.

	Cracked wheat.	Cracked barley.	Wheat shorts.	Wheat bran.	Cracked corn.
Dry matter.	82.	80.	76.	69.	90.
Ash	50.	6.	5.	6.	1.
Ether extract	70.	79.	70.	75.	78.
Protein	80.	81.	75.	75.	90.
Fiber	60.	48.	33.	30.	48.
Nitrogen-free extract	83.	86.	86.	70.	94.

When corn and wheat are both selling at fifty cents per bushel, the fifty cents will purchase the same amount of digestible dry matter of either wheat or corn, but the digestible dry matter in the bushel of wheat contains two and one half pounds more of digestible protein, while the bushel of corn contains two and one half pounds more of digestible carbohydrates. The amount of heat units produced by each grain is about the same.

TABLE LXIV.—Digestible Nutrients in a Bushel of Wheat and Corn.

	Dry Matter.	Fat.	Protein.	Carbo-hydrates.	Heat Units.
Wheat	43.5	1.	7.	35.	82.345
Corn	43.5	1.5	4.5	37.5	84.407

Inasmuch as the bushel of wheat contains more digestible protein, this food is better suited to produce pork with more lean meat, than is corn. Furthermore the manure from the wheat is worth about twenty-five per cent. more than the manure from the corn.

UNIVERSITY OF MINNESOTA

AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 37.

ENTOMOLOGICAL DIVISION.

DECEMBER, 1894.

THE CHINCH BUG.

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.

ST. PAUL:
THE PIONEER PRESS CO.,
1895.

UNIVERSITY OF MINNESOTA.

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THE CHINCH-BUG.

OTTO LUGGER.

There can be no reasonable doubt that this pest will greatly injure our crops of cereals in 1895. During the last year these insects have become very numerous and have migrated to many parts of the state where formerly they could not be found. As these insects use their wings much more freely when leaving their hibernating quarters in the spring, the probability exists that a still greater part of the state will be invaded. At present they are found in nearly all the more wooded districts of the southern and central parts of Minnesota, and only the open prairies have escaped. In the northern part of the state they have invaded many portions of Otter Tail, Wadena, Crow Wing and Pine counties, and are found, perhaps only in exceptional cases, even in the pine regions still farther north. In fact, they were found upon several small farms near the shore of Vermilion Lake, where the only agricultural products were potatoes and a little timothy. In one case a patch of timothy surrounded by evergreen trees was utterly ruined by them, and close questioning brought out the fact that chinch-bugs had been causing similar damage to the same patch for at least three seasons, thus plainly proving that this insect can survive even exceedingly cold winters without being much injured. As far as our prairies are concerned, those adjoining the wooded banks of rivers and lakes are more or less infested with this pest; and as the windbreaks offer excellent shelter for it during the winter, there is danger that the chinch-bugs will invade a steadily enlarged territory.

The past history of the chinch-bug teaches us that its increase and decrease may be compared with ocean waves striking a shore: at first a gentle swell, then a small wave, followed by a tremendous breaker. In other words, it takes a number of years before the insects become numerous enough to cause immense losses. Like the sudden collapse of the breaker, chinch-bugs, having reached the period of greatest destructiveness, also become suddenly reduced in

numbers and are past doing harm for a number of years. This forecast would be a very pleasant one if the bugs in Minnesota had already reached this culmination point of their increase, which unhappily is not the case, and we may reasonably expect increasing trouble for at least two years. Past experience has shown that we may expect at most two chinch-bug years in every seven years, with the strong probability that there will not be two in succession; it is only a pity that this rule should never have exceptions, which, however, it has. At all events, such experience ought to warn us to be always prepared for the enemy and to apply remedies in time and not wait until too late.

The cause for this rapid increase in their numbers was evidently the exceedingly dry and warm season of 1894. Even the oldest inhabitant of the state does not recollect a season like the past one, which is a singular fact considering how apt some wiseacres are to recollect things—in imagination. In many portions of the state rain fell only at very rare intervals and dew was almost unknown. If it had not been for the frost in May, following very warm and moist weather, which forced the roots of cereals to penetrate deep in a soil warmer than the air, damages by the drouth would have been still greater. It was really surprising that plants could grow at all during such a season. The dry and warm conditions of soil and air are just the conditions chinch-bugs require to thrive and to multiply, and from the few bugs found here and there in isolated localities sprung the great and almost connected armies of chinch-bugs found late in 1894. Yet notwithstanding these favorable conditions for the existence of these bugs, farmers lost, comparatively speaking, but little on their account, simply because the earlier cereals, such as barley, wheat, rye, and even oats, matured much sooner than usual, and thus became unfit for their food.

After injuring to some extent the corn, or causing in some cases a total loss of that important crop, and after destroying such grasses as the different kinds of pigeon grasses, to the latter of which they were decidedly welcome, the chinch-bugs moved about in search for suitable shelters under which to pass the winter. A large number of such shelters have been investigated in various parts of the infested regions, and almost invariably with the same results: immense numbers of chinch-bugs were found snugly hidden, ready to commence their destructive operations early next spring. In most cases

the great majority of these dormant bugs were found to be decidedly healthy, and only in some localities a disease is silently at work reducing their numbers. Diseased bugs were found in their winter quarters only in regions where a disease had been spread artificially in 1894; not a single diseased bug has been found elsewhere.

Life History of the Chinch-Bug.—It seems to be unnecessary to give the life history of such a well known insect, which has repeatedly caused such vast losses to part of our state, but a large number of our farmers have had thus far no opportunity to become familiar with their enemy. This is chiefly true of regions not yet or only quite recently infested, and where this tiny insect has not been discovered to be such a formidable foe. That many farmers, even living in regions where chinch-bugs have caused considerable damage, do not yet know this pest is plainly proven by the fact that all sorts of insects are sent to this Station with the question: Is this a chinch-bug? Among such specimens received are insects which do not resemble chinch-bugs in size, shape, color or general appearance, but all are fairly large, showing that small insects are considered too insignificant to annoy the "crown of creation." Yet it is among the smaller insects that our greatest enemies are found. A large number of small insects, but mainly bugs, are frequently mistaken for the genuine chinch-bug, simpy because they smell bad. Chinch-bugs have, indeed, a bad odor; but other bugs produce the same or a worse by being squeezed. In illustration Fig. 1 are given all the different stages of this insect, and by comparing a doubtful specimen carefully with these figures farmers not yet familiar with the chinch-bug will have no trouble in ascertaining their true character.

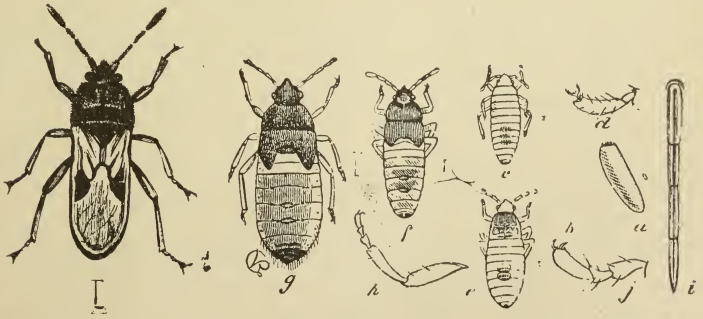


FIG. 1. Different stages of the Chinch-Bug, showing Egg, Larva, Pupa and Adult. After Riley.

The adult and winged chinch-bug (*Blissus leucopterus*, Say.) is three-twentieths of an inch long, and has a black body covered with a very fine grayish down, too fine to be plainly visible to the naked eye. The four-jointed feelers possess a honey-yellow basal joint; the second joint is tipped with black; the third and fourth are black. The beak, when not in use, lies hidden between the legs, and is brown. The wings and wing-covers are white; the latter have near the middle two short, irregular black lines and a very conspicuous black spot near the margin. The white wing-covers, with the contrasting black spot, distinguish the chinch-bug from all other bugs found in Minnesota. Of course, whenever an insect becomes so very numerous as the chinch-bug, many forms can be found which vary somewhat from the description given. Even forms may be found which possess only rudimentary wings, and this is most frequently the case in the first generation, when these insects do not readily use their wings. The black spot upon a white ground is, however, always plainly visibe.

All chinch-bugs pass the winter in the adult, winged or perfect state, never as eggs, larvæ or pupæ. Towards autumn, when their food supply, such as corn and wild grass, becomes too dry to furnish sap, the bugs are forced to search for some convenient and suitable shelter in which to pass the winter. But in doing so they seem to know exactly what is a suitable shelter and what is not. The aim of all seems to be to find a dry situation; one that is either somewhat elevated to afford good drainage, or one composed of such soil as sand, that will permit moisture to disappear quickly. In such situations the bugs hide under dead leaves, bunches of tall grass, under all sorts of rubbish, under logs, stones and clods of earth; they also find shelter under haystacks, strawstacks, corn shucks—even under loose bark of trees and in outhouses. Most chinch-bugs hide near the edge of woods growing upon an elevation, under rubbish upon sandy soil, or under the mulching in windbreaks. Here they remain torpid during the cold weather, but during a continuous warm spell in winter they are apt to move about a little, perhaps to find still warmer quarters. Extreme cold weather has no terrors to chinch-bugs; in fact, the colder the winter the safer they pass it, providing, however, that no repeated thawings and freezings take place, which will injure their vitality. A bug that can safely winter upon the shores of Vermilion Lake cannot be frozen to death by any weather that may occur elsewhere in Minnesota. Last winter a

number of chinch-bugs were found hidden in a short bunch of grass in a lawn, and by sprinkling water upon bugs and bunch the ice formed at once, keeping the bugs hermetically sealed for several months. Upon thawing this ice the bugs acknowledged their obligations by destroying some tender and choice grass plants. The general opinion that a severe cold winter will decimate our insect enemies is based upon no facts; on the contrary, an open winter, with repeated thawing and freezing, is more apt to assist us against this enemy, but to what extent it is impossible to state.

As soon as the soil becomes warmer towards spring the bugs show greater activity during the warmer portions of the day, and are very apt to crowd together in spots particularly warm. At this time they do not yet require food. But as the nights become also warmer they commence to show their appetite by tapping the tender grasses now appearing. Towards the end of May, though sometimes much earlier or later, according to the climatic conditions of the season, the bugs become decidedly active. In exceptionally early and warm springs, mating takes place in many cases before leaving their hibernating quarters, though as a general rule it does not occur until breeding places have been selected. During a long-continued warm and dry autumn, mating chinch-bugs are not so very uncommon, yet such cases are an exception, not a rule. When the proper time arrives, all the bugs take to their wings and fly about in search of food for themselves and for their prospective offsprings. Not infrequently the air is filled with their winged bodies, and this is sometimes the only time that they attract general attention, as they frequently entirely cover horses, wagons and persons. This is a critical period for fields that have so far escaped their ravages. As the weight of such bugs is but slight, they can be carried away by the winds to very distant localities. In fact, the stronger the wind at this time the farther the trouble may spread. This no doubt accounts for the presence of the chinch-bug in regions but poorly adapted to their requirements; for instance, in isolated meadows surrounded by dense pine forests. This is also the time when the otherwise safe western prairies of our state may be invaded for the season, and if sufficient shelters can be found in windbreaks the pest may be established in this newly conquered region for several years. Such flights only take place when the air is dry, and only during the heated portion of the day. The reason for such flights is self-evident; they are made to find feeding places for themselves and for their

offsprings. But not every field with inviting young plants of barley and wheat has attraction for such insects; the fields must be of a certain kind. Fields with a sandy soil, well drained by being situated on a knoll, and which warm up readily, are preferred; or fields that either from being poorly cultivated or from being more or less exhausted of vegetable food, have a poor stand of plants. Such fields are almost invariably selected simply because the soil is exposed to the direct rays of the sun, and because chinch-bugs dearly love warmth and dryness. When settled in their new home the bugs make up for the long fast enforced upon them by the winter, but soon afterwards the sexes commence to mate. Those that had already mated soon commence to deposit eggs, and thus the egg-laying season lasts four weeks or more. A field may contain untold numbers of bugs and yet have but very few visible, and those nearly all in the act of mating, which usually takes place upon the ground. By shaking the plants—or, better by pulling them up with their roots—the true state of affairs will become painfully visible. The great majority of the bugs enter the ground for protection, and obtain their food by tapping the lower parts of the stalks of grasses and cereals. Though not equipped with legs fit for digging, they find an entrance near the plant, made for them by the swaying of the stems in the wind. Here they enter and make their homes, surrounded by plenty of food—the sap of nearly all species of the grass family.

The egg is rather large for such an insect, measuring about 0.03 inch; it is elongate oval, with the diameter about one-fifth the length. By observing such an egg with a powerful lens, it will be found quite a pretty affair. It has a squarely docked top, surmounted with four rounded tubercles near the center. As long as quite fresh, it is pale, whitish and translucent; as it grows older it becomes amber colored, and towards the period of hatching the red parts of the future insect, but especially the eyes, are very plainly visible towards the top. These eggs are almost invariably deposited upon the roots of the plants selected, and only exceptionally can they be found upon the withered sheaths near the base of the stalk. As the eggs are usually deposited in small clusters, they are readily detected with the naked eye. By pulling up such plants and inspecting carefully the roots and base of stalk, the eggs appear as glistening objects of amber or red color, quite distinct from similarly colored grains of sand. Of course a large number of the eggs become de-

tached and remain in the soil when pulling the plant, so that those counted give by no means a true estimate of the numbers really present. It is claimed that each female can deposit as many as 500 eggs. When we consider that the egg-laying period of a female bug extends from ten days to four or five weeks—in some cases over even a longer period—and that eggs may constantly mature in the ovaries, this large number is very likely to be only too correct. There is considerable difference in the length of time required to hatch eggs. Last year eggs deposited quite early in June remained almost three weeks in the ground before hatching; later the hatching time was considerably shortened by more favorable weather, and the eggs hatched on an average in two weeks. Eggs of the second laying hatched, in some cases, inside of ten days, everything being in favor of a rapid development of the embryos.

Larval Stages.—As soon as the young larvæ hatch they lose no time in inserting their beaks to obtain the liquid nourishmnet of the plant. This action frequently takes place before the young bug has seen the light of day. Of course a great deal depends upon the weather existing at the time. If warm and dry, the young bugs work their way towards the surface and usually insert their beaks in the stalk just above the surface. The character of the soil has also considerable influence in this respect. The newly hatched larva is pale yellow, ornamented with an orange stain upon the middle of the three larger abdominal joints. A glance at Fig. 1 will show this, as well as the other differences pointed out later. In shape this young bug resembles the adult insect, being but slightly longer in proportion. Yet it differs in one point essentially from the adult by having but a two-jointed foot. Of course this otherwise curious difference will not greatly interest the farmer. As the infantile bug grows older the red color soon pervades the whole body, except the first two abdominal joints, which remain yellowish. As the larva enlarges it soon outgrows the outer skin, which can not expand, and the insect is forced to throw off the old coat and wear a new one of a bright vermilion color, in strong contrast with the pale band across the middle of the body. Growing rapidly, the larva has again to undergo a second molt, after which the new coat shows a dusky head and thorax. At this time the future wings become indicated by small, dusky wing-pads. Molting a third time, the pupal stage has been reached. The pupa has a brownish-black head and thorax, larger wing-pads of a similar color, a dingy gray abdomen, and a

dark horny spot at tip of abdomen. The entire body is also slightly pubescent. The pupa, as well as the larva and adult, takes food by inserting its beak in the food plant.

The adult bug has already been described. It is distinguished not only by having a different color, but by being larger, winged, sexually mature, and by having one toe more in each foot. As already mentioned, a great number of somewhat differently colored and shorter winged forms have been described, but none are of a pleasing aspect to the farmer.

The time required to transform a freshly deposited egg into an adult bug varies greatly in different seasons, as might be expected in case of an insect so fond of warmth and dryness. In wet or cold seasons it takes much longer, but if conditions are favorable these changes may be passed through in fifty-six to sixty-two days. Sometimes, long before the last produced larvæ have reached the adult or even the pupal stage, such food as rye, barley and wheat becomes too ripe to furnish the needed sap, and the bugs are forced to travel in search of plants more suitable for their food.

Migration.—The above accounts for the peculiar fact that the migrating armies of chinch-bugs, when leaving the fields of small grains for those of green corn, are composed of all ages, forms and sizes. In some cases nearly full-grown larvæ compose the majority of the army; again, small and large larvæ and pupæ form the bulk, but most usually a large number of adults are among the migrating insects. Climatic conditions and the resulting fitness or unfitness of the food-plants are the main cause of this peculiar state of affairs. As a very general rule, such armies do not and can not travel very fast nor far, and seldom a distance of over one hundred rods is passed over. Of course, hunger is a very severe prompter, and almost all bugs leave a field no longer furnishing food at nearly the same time, and all—prompted by the same sense or instinct—move in the same direction, and almost invariably to the next field of corn. What this sense may be is difficult to state; perhaps an acute sense of smell, perhaps some sense we do not know anything about, not possessing it ourselves. Notwithstanding the fact that the adults found in such an army possess wings, they use them but very seldom, and only when the air is very warm and dry. Such winged insects may fly to the next source of food, or may be blown by the winds arising during their flight to far-away regions, to form the starting point of a new colony or a new army. All attempts to force such winged

insects to fly are of no avail; they evidently trust more to their legs than to their wings. An army of migrating chinch-bugs would be a sad sight if they were friends and not enemies. They appear foot-sore and dusty, and surely are hungry and thirsty. The individuals move rather quickly, and readily overcome common obstacles that may impede their march. But if they encounter dusty paths and roads, or newly plowed, dusty fields, they have a desperate task before them. In such dusty places, heated by the direct rays of the sun, and not compressed by rain or dew, their progress is necessarily but slow. As they move their front feet forward, grasping a particle of dust, this latter gives away and is pulled towards the insects whenever they attempt to press forward. Thus a dusty road becomes an obstacle almost impossible to cross. Yet the hunger and thirst permits no cessation of work, and many insects will at last succeed in overcoming all obstacles. A heavy dew, or a slight rain, is of course of great assistance to the moving army, and a dusty road no longer is impassable. The sun, which chinch-bugs enjoy so much at other times, becomes at this period a source of great danger, and many of the younger and less efficiently protected bugs die in consequence. All these facts ought to point out to the farmer many a method by means of which he can conquer his enemies. In the end, all obstacles are surmounted by those bugs that did not perish from hunger or heat, and the surviving members succeed in reaching the land of plenty—a waving field of corn, with vivid green and succulent food. Nor are the bugs slow in utilizing these new stores, and they are so hungry that they settle upon the first plant they reach. Soon the famished army covers the outer rows of plants of a cornfield, and we can now for the first time realize how numerous they were in the fields abandoned by them, since the scattered insects are now concentrated upon a few and large plants. These plants of corn soon turn black by the very presence of the insects. At first only the base of the stalk is thus crowded, as the tired bugs attacked that part of the plant reached first; but soon afterwards the whole plant, to the very extemities of the leaves, is covered with them. Their united action forces all the sap of the plant to the outside, and as there is at first usually more sap than the bugs can well imbibe, the spaces between the sheaths of the leaves become filled with fluid, which in a very short time ferments and sours. If the bugs would simply be satisfied with imbibing sap, they would greatly injure the plant; but they cause still greater damage by injecting some

poison which browns or blackens the leaf surrounding the part injured by the beak. Thus even comparatively few insects, not numerous enough to kill a plant, will cause it to wilt or die by the action of this poison. A similar action can be observed in a domesticated species of bugs not seldom found in beds. These insects, instead of thriving upon vegetable sap, prefer that of animals, and to fill their hungry stomachs as quickly as possible they insert their beaks into the human skin, inject an irritating poison to cause a local inflammation, and thus force a rapid flow of blood to the injured part. Perhaps for a similar reason is poison injected into plants by chinch-bugs attacking the same.

Gradually the chinch-bugs of this first generation mature, and, after mating, deposit eggs for a second and last brood. These eggs are usually deposited behind the old and withered sheaths of the lower leaves, where they may be found quite readily, and in large numbers, not being so much hidden by particles of soil as those laid earlier in spring. Under such sheaths the young bugs hatch and feed, sometimes even undergoing all their metamorphoses to the adult stage. Most larvae, however, leave these shelters, because they are too crowded, and search for more suitable places upon other plants. In this manner soon most of the plants in a field are crowded, and suffer in consequence. The outer rows of corn, so thrifty looking at first, soon cease to furnish food, and after the insects have left appear white and bleached. In very severe cases, a cornfield badly infested can be distinguished from all others by this bleached appearance; and, as this usually happens during our hottest and dryest season, even repeated showers of rain are unable to strengthen and revive such plants. Whoever wishes to study the power of insects to destroy and to increase needs only to pull down a leaf of a corn plant infested with chinch-bugs. He will find, snugly hidden beneath the sheath, immense numbers of these insects, together with the discarded coats of the earlier stages of this bug. In course of time all these insects mature, and as their supply of food commences to flow more sparingly, or ceases altogether, it is time for them to search for shelters under which to pass the winter. Many of the insects remain for this purpose under the very sheaths that offered them shelter and food thus far, but the great majority now make good use of their wings and scatter far and near. As their usual winter quarters have already been described, it is not necessary to repeat.

This is, in a general way, the life history of the chinch-bug. It varies somewhat in details in the different regions or in different seasons, but as far as Minnesota alone is concerned, no essential facts have been omitted. It might be added, that during their migrations to the cornfields, these injurious insects become useful by destroying all the pigeon grass growing in the abandoned fields and upon the route over which they pass.

Vulnerable Points in Their Habits.—When we consider the life history sketched above, we find that a practical person will be very apt to discover some habits that could be utilized to kill large numbers of this pest. Considering the fact that these bugs find shelter under all sorts of rubbish, leaves, etc., it appears assuredly feasible to attack them there with good results. Clean farming, then, is not only goodly, but an excellent remedy against this insect, and against many others. Let every farmer do his share of the work by not permitting any rubbish to accumulate upon his farm. In our usually dry autumns all rubbish will burn well. Such material should be raked together in rows; this should be done before the bugs search for shelters, and as they surely will find such rows, they will not be slow to appropriate them for winter quarters. Later, rubbish and bugs can be disposed of by fire. This work should include the clearing and cleaning of the edges of the woods, of fences and fence corners, of haystacks and straw-stacks, of windbreaks; in fact, no rubbish should be permitted to remain upon the farm; and no rubbish means no shelters for the bugs. Besides this all the taller grass should be burned over; in fact, let the fire be anywhere and everywhere excepting where it might be dangerous. This burning of dead foliage upon fields, meadows and prairies in former times accounted, to a great extent, for the absence of many injurious insects at present only too common.

We know that chinch-bugs prefer certain plants and dislike others; they prefer millets, for instance, and almost invariably attack this plant when found in the infested region, while flax repels them. It seems that barley is their second choice, then wheat, and later in the season corn. Winter rye frequently escapes harm, as it usually ripens too early, though a great deal depends upon the season, and rye may be destroyed by preference. Chinch-bugs do not like oats. This does not mean, however, that oats will invariably escape their ravages. On the contrary, if more suitable food should be scarce, chinch-bugs consider oats good enough for them, and act

accordingly. By sowing millets very early, and having it above ground before the bugs leave their winter shelters, they will assuredly find and appreciate it, and will settle there in very large numbers. Of course, the owner of such millet cannot expect to grow both a crop of millet and of bugs, but will be forced to sacrifice the former to kill the latter. Just before the millet becomes too hard for the insect, it should be cut and left upon the soil. The bugs remain upon it for some time before realizing the necessity of migrating, and this delay should be utilized to burn millet and bugs.

Another point in the life history of these bugs is their love for warmth and dryness, and consequently their selection of fields offering both. Chinch-bugs prefer sandy soil or poorly cultivated soil simply because in such fields the plants are small and of irregular growth, thus permitting the sun to strike the soil directly, it not being shaded by foliage. Fields well covered with plants, and consequently soils well shaded, are not attractive to these insects. A good farmer will not utilize soils of the above characters, but will enrich the sandy soil to such an extent as to produce a strong and uniform stand of plants; nor will he cultivate poorly a good soil; neither will he be a robber of the soil by continuing to remove crops year after year without returning something to the soil in form of manure to keep up its fertility. A good farmer will escape many losses by insects and other pests where a poor farmer would suffer. Good farming, and clean farming, should be the motto over every farmer's door. Poor farming means also a rank growth of weeds, and mainly of the different species of pigeon grasses, which in themselves are a great attraction for chinch-bugs.

Another point in favor of the good farmer, or of one who feeds the soil generously, is a return of the thankful soil in form of strong and vigorous plants; plants which can withstand the attacks of injurious insects much better than the weak plants growing upon a starved soil.

As long as it is the aim of the farmer to grow upon the biggest scale possible only one kind of crop, just that long noxious insects will be numerous, or even increase still more in numbers. The reason for this is so self-evident that it is not even necessary to explain. If more diverisified farming was the rule and not the exception, as it is at present, fields containing the same kinds of plants would be more or less widely separated by fields containing other kinds of plants, and insects would not find it so convenient to multiply with-

out let or hindrance. Such fields of cereals, separted by other fields containing other crops, would soon reduce the numbers of many insects, and among them those of the chinch-bugs. Of course, this would mean, perhaps, more work, but it would also mean less trouble and better returns for the labor expended.

When we consider the method in which the bugs of the first brood migrate from the dry plants first infested to the future green food in cornfields, we are struck with the fact that nearly all bugs, whether large or small, migrate on foot, and that even the great majority of the winged ones do not form an exception by using their wings. Of course, under certain conditions a small percentage take to their wings; but this is the exception and not the rule. Armies of insects migrating on foot, and moving slowly and in the same direction, should offer us many opportunities to oppose or to stop them entirely. This very fact of migrating on foot is the weak point in the life history of the chinch-bug, where we can, with a little foresight, overcome them. Many different methods may be adapted, depending mainly upon the character of the ground over which the insects have to pass. In our own state the agricultural soils are usually quite free of rocks and stones, excepting certain localities where they abound, but where, in consequence, but little grain is grown. By making between grain and cornfied a ditch several feet in depth, immense numbers of bugs can be captured and killed; in fact, nearly all that travel on foot. But in dry summers such ditches will have sides composed of baked and hard soil, and would offer but a slight hindrance to the moving army beyond extending their trip over a little greater distance. It is therefore necessary that the sides of such a ditch should be smooth and that its bottom should be very dusty. This latter is easily managed by tying together a bundle of twigs, with the leaves still adhering, and by dragging this bundle repeatedly through the ditch until the desired conditions have been made. The spade should be used to rectify any defects in the smooth sides. If such a ditch cannot be made, one or more very deep furrows should be plowed, and by using bundles of twigs their bottoms should be made very dusty. Very fine dust will perform the work most thoroughly. As already mentioned, it is almost impossible for a bug to cross such a dusty strip. Many modifications of this method are possible and will suggest themselves to the thinking farmer. Even a strip of plowed land, made perfectly level with a disk-harrow and thoroughly rolled by a heavy roller and made

dusty, will do wonders. All these methods have two ends in view: to stop the progress of the bugs and to collect them in large numbers in a limited space, so that they may be killed. This latter can be done in various ways. If ditches are used, a little straw scattered in the bottom will soon be crowded with bugs; in fact, piles of straw seem to confuse the traveling bugs and retard and retain them for some time. The straw can be burned by adding a little kerosene oil. Or, by means of a post-hole augur, holes can be made every ten or fifteen feet, into which the bugs will collect or into which they may be swept. By closing such holes when filled with bugs and making other holes, or by killing the bugs in the holes by kerosene oil and cleaning them afterwards with the augur, the bulk of the army can be captured and disposed of. As the bugs will not cross coal tar, the edges of furrows or ditches towards the fields to be protected should be covered with this material, and none of the insects could leave the trap. This coal tar can also be used even without a ditch or furrow, but will not be so effective; yet in certain and extreme cases it may be the only method that can be used in time. By pouring a broad line of this material upon the neutral zone between the fields, and by keeping its surface fresh, the bugs will gather in front and can be trapped in holes made for this purpose. If all such measures have been neglected, or if the bugs have already reached the outer few rows of the corn, the plants in them should be cut down in such a way that they form more or less continuous piles upon the ground. The bugs, being starving, will not leave these stalks for some time, but will continue to find their sustenance upon them. This, for quite a while, prevents their moving to the next rows of corn. The bugs can be killed in very large numbers by burning dry straw between the piles of corn cut down. A little kerosene oil, or any other substance that burns well and makes a dense smoke, will make a very pleasing addition to the entertainment. Knowing the principle to be applied, every thinking farmer ought to know how to apply it to the best advantage upon his own fields. The very fact that the bugs are retarded for a long time upon the heated surface of the ground is sufficient to kill a large number. The same principle explained above, but in another form, was applied by the writer six years ago upon the fields of the Experiment Station, and with such marked success that the corn to be protected did not suffer in the least from the chinch-bugs, though they almost surrounded the cornfields in immense numbers. The description of this particular case will be quoted later.

It seems strange that sensible farmers, who have been told again and again, should fail to make use of such a very simple and cheap remedy, simply because it requires some extra work. And yet this work is required to be done at a time when other farm work is not so very pressing. If these methods were only generally and conscientiously followed, there would be no need to apply other remedies; and not alone would the corn be saved, but in saving it the second brood of chinch-bugs would be very materially reduced in numbers, and in a short time the chinch-bug would cease to be the destructive insect it now is. As this method is such a good one, it bears repetition: all that is required is a thoroughly dusty surface, best in a depression especially made for that purpose, and that this dusty surface should be attended to diligently, so that repairs can be made whenever necessary. A ditch or furrow left unattended will be made in vain.

Although most of the direct remedies—the insecticides now in general use—will prove of but little value, we should except the kerosene oil emulsion, which can be used very successfully in certain cases. If the migrating bugs have reached the outer rows of corn, and almost hide these plants by their presence, this material will prove very effective; and as it will cost less than 75 cents per acre, it should be used much more generally. The emulsion should be well made, and it will be found best to use the one made after the Hubbard formula, which is here repeated:

Kerosene, 2 gallons	67 per cent.
Common soap or whale oil soap, one-half pound)	
Water, 1 gallon)	33 per cent.

"Heat the solution of soap and add it boiling hot to the kerosene. Churn the mixture by means of a force pump and spray nozzle for five or ten minutes. The emulsion, if perfect, forms a cream which thickens on cooling, and should adhere without oiliness to the surface of glass. Dilute before using one part of the emulsion with nine parts of water. The above formula gives three gallons of emulsion, and makes, when diluted, thirty gallons of wash." To do the work thoroughly, farmers should use this wash at the rate of about sixty gallons to the acre.

Relation of the weather to Chinch Bugs.—Most persons have the impression that a very severe and cold winter would prove fatal to chinch-bugs. This impression or belief is not borne out by facts, which prove that the opposite is nearer the truth. An uniformly

cold winter, and a more or less deep covering of snow, are the very conditions that chinch-bugs require to pass the winter in good health. As soon as the cold weather begins, they become torpid, and remain so until spring. If, however, we have an open winter, with little snow, or long mild spells warm enough to wake up the torpid bugs, followed by very cold periods, or if we have frequent freezing and thawing, then the bugs suffer more or less severely, and their vitality becomes impaired and weak, and they are ready to succumb to any disease that may attack them. This is especially true if large numbers of bugs crowd together in the same hibernating quarters. It seems as if a deep covering of snow was essential to their health. Yet immense numbers of bugs remain frequently unimpaired and healthy without such a cover, and wake up quite active in spring, not showing the least ill effect of such a long exposure to cold. If we investigate such hibernating places we soon discover that they are dry, or that they are well drained. It seems, then, that it is moisture more than cold that chinch-bugs try to escape. They are not easily killed when in a state of torpidity, and we can have no assurance that they may be killed by the inclemency of our winters. Their love for dry shelter accounts for the fact that a long continuous wet spring is fatal to their health. They cannot escape this moisture, and large numbers of bugs can be found dead after such a rainy spring. This accounts, also, for the fact that a rainy season usually causes the end of a chinch-bug invasion. The insect becomes weak and the prey of various diseases which seem to be always ready to attack bugs with an impaired vitality, and during such seasons the great majority of bugs are killed. An uniformly cold winter, with much snow, an early spring not too wet, followed by a warm and dry late spring and a still warmer and dry summer, are the essential climatic conditions favorable to a rapid increase of chinch-bugs. Knowing that immense numbers of chinch-bugs are now sheltered in their winter quarters, and that at the present time (Dec. 10, 1894) they are still in a most healthy condition, it is to be feared that a considerable part of next year's crops will be subjected to their ravages. As we cannot tell beforehand what kind of weather will prevail in spring and early summer, and as rain-makers have apparently lost a control they never possessed, it well behooves us to make all the preparations necessary to fight the enemy. Every farmer ought to be willing to do his share of the work, and by carrying out conscientiously the different methods given above—all

based upon the habits of that enemy—very much may and should be done. Yet the millennium has as yet not been reached, when every farmer will be educated and willing to undertake such work, and we must therefore depend upon other remedies, which should be applied largely by the state for the benefit of the entire community, as large crops are the mainspring to the activity of every other business besides that of farming.

It is well known that the area of wheat and of other plants belonging to the family of grasses stands in the same relation to losses caused by chinch-bugs as cause to effect. Districts in which most wheat is raised feel the damage first and most severely; those in which wheat and oats are the principal crops next receive the brunt of the insect attack; and the last to be seriously affected are those in which corn and grass are the leading products (Forbes). In a region in which stock-raising and dairying are the leading agricultural pursuits the bugs are less liable to cause damage than in a region in which small grains are the staple crops. Prof. Forbes has also demonstrated that large areas of oats could be successfully grown, but in corn-growing regions most small grains should be left alone, and, above all, winter wheat and barley.

Diseases of the Chinch-Bugs.—Considerable attention has been paid during the last ten years to a number of diseases that are known to be fatal to such bugs, and considerable progress has been made in their application. Such diseases have been studied, and methods have been invented in which they can be increased and spread among their victims. Still, a large amount of work and innumerable experiments have to be made in this direction, and it is still an open question whether we shall ever so fully succeed as we wish to. None of these diseases can be called as yet a true remedy, as we can do but one part of the work, while climatic conditions must do the other. It is easy enough to produce any amount of fungi causing such diseases, but we cannot produce the necessary weather to make it effective. All such diseases seem to require two distinct conditions: a fair amount of moisture to make such plants as fungi thrive well, and a somewhat lowered vitality of the bug to be attacked by the disease. Under artificial conditions we have control over both, and can consequently produce from a few fungi a very large number of diseased and fungus-covered dead bugs. But when we introduce this material among the healthy bugs found in our fields we lose control of the necessary conditions and have to depend upon the weather that may be prevailing at the time. If this is in favor of

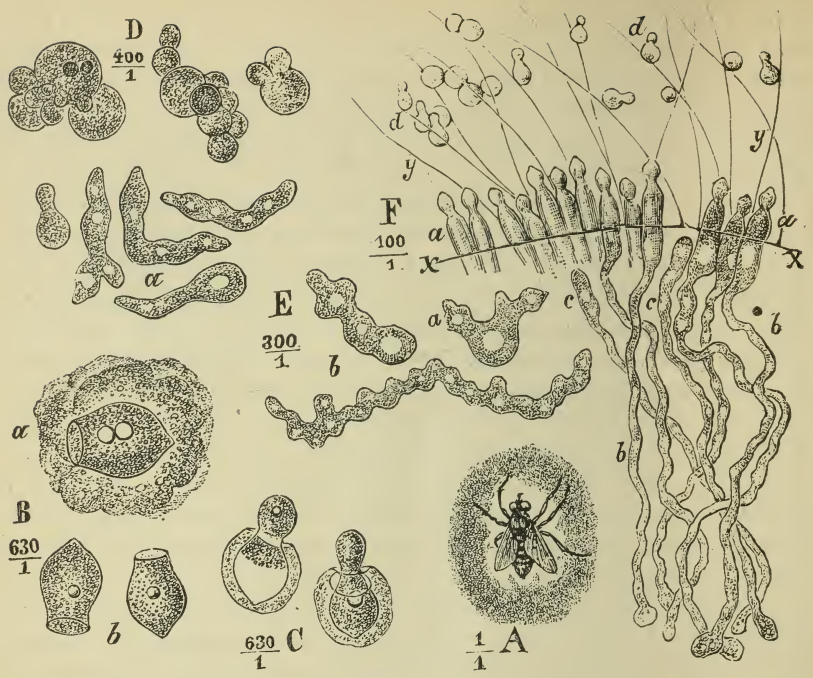


FIG. 2. Disease Killing the Common House-Fly.

the death-dealing fungi, the introduction of a disease will be a success; if not, it will do but little good. In other words, if the disease is introduced when the weather is favorable, good results will follow; if dry, none may be expected. As the diseases are chiefly active during the warmer portions of the season, they make but slow progress during the time that the bugs hibernate; yet late summer and autumn rains have a tendency to promote the development of a very virulent disease of the bugs, the *White Muscardine*. Persons who are in the habit of watching such things have no doubt observed how rapidly our common house-flies are killed by a disease prevailing in September. Not infrequently we may at this time observe a fly fastened by its tongue to a pane of glass in a window, surrounded by a white, flour-like dust. If the fly is removed, its body will be found hollow. This white dust is in reality composed of spores of a fungus which grew inside the fly, and after killing its host, forced its way to the surface of the same and scattered these spores, again fatal to other flies that may come in contact with them.

The disappearance of the multitude of flies early in September is not owing directly so much to the colder nights that prevail at that time as to the disease and death-producing fungus. We do not observe this disease during the warmer portion of the year, simply because the vitality of the flies will permit them to escape this contagious disease. But as cool nights become the rule and not the exception the vitality of the fly is lowered; flies crowd together in large numbers ,are more or less sluggish in all their actions, and consequently the disease requiring such conditions can attack and kill them. The same holds good with all diseases of this nature that attack chinch-bugs; perhaps it is the general rule with all diseases caused by such small parasitic organisms.

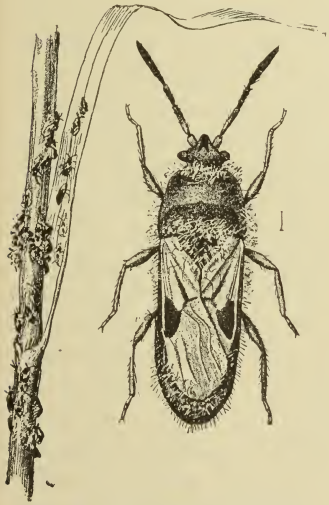


FIG. 3. Chinch-Bug Killed by Entomopthora.

FIG. 4. Bug Covered by Mycelium of Sporotrichum.

In Fig. 3 is shown a chinch-bug, greatly enlarged, that was killed by a species of fungus (Entomophthora), and which was the cause of the sudden disappearance of chinch-bugs from the state in 1888. As the case was a very interesting one, showing at the same time another method to prevent bugs migrating from the neighboring cornfields, the statement made at the same time is here repeated: "Oats, rye, wheat and some grass was utterly destroyed by them, and the young and promising corn formed now a standing invitation

to the hungry hordes. To prevent their inroads, all the infested fields and experimental plats were surrounded by a low board fence, six inches high, and snugly fitting to the ground, so as to prevent the insects from crossing under this fence. The upper edge of the boards were painted from time to time with tar, which prevented the bugs from crossing. The insects were at this time of all sizes and ages; adults of the first brood, young hatched bugs and pupæ were all mixed together, and all were decidedly hungry, as their intense activity and the swarming armies of famishing bugs plainly indicated. To gather in this crop of bugs, round holes, about six inches in diameter, were drilled in the ground close to the fence, and as one hole became filled with insects it was closed and another one was opened close by for the reception of more victims. So matters worked to our satisfaction, when an unexpected assistant came to help us, making the construction of more fences unnecessary. The above-mentioned holes were quite deep, and consequently were all wet, a condition of things not at all suitable to starving chinch-bugs, and they soon became unhealthy and weak, thus presenting the best conditions for any disease to claim them as its victims. And such a disease, produced by a fungus, was not slow in making its appearance, as could be seen by the numerous dead bugs. The margins of the holes, but chiefly those most densely crowded with captives, became whitened with dead bugs, enshrouded in white mycelial threads and dust-like spores; in fact, in a few days the upper rims of these holes looked as if recently whitewashed. Nor did the disease stop there! On the contrary, it spread very rapidly to adjoining fields of timothy, Hungarian grass, millet, etc. Even the course followed by it from the holes could be readily recognized for some time by the more or less numerous white spots left in its wake. The fields invaded by the disease afforded, upon closer examination, a truly edifying spectacle to those not interested in the welfare of the chinch-bugs. They looked quite panic-stricken, and moved about in a slow and dazed way, figuratively speaking, as if badly scared. And well they might be! The victims of the disease could be seen everywhere by the thousands; they had been slaughtered in all kinds of positions, but they were usually fastened to the blades and stems of the grass, or to the leaves of the young clover. All showed plainly that their last and strong determination in life had been to hold on as long as possible; their legs were firmly planted upon the substance where the bugs happened to be; others

had only their beaks inserted and were dangling by it free in the air. But all showed the characteristic white mycelium threads and spores of the disease. The illustration in Fig. 3 shows an enlarged chinch-bug, with white threads issuing from its body, and numerous other specimens in natural size killed by the fungus. Although almost exclusively attacking chinch-bugs, the disease was not slow in slaughtering such small flies as found the society of such malodorous companions to their taste. A story with a moral." "Most, if not all, the chinch-bugs would have been killed at the Experiment Station, if the suitable conditions for the disease had lasted a few days longer. But the wet spell which prevailed part of the time the disease was playing such havoc amongst the bugs soon passed and was followed by warm and very dry days, which soon stopped any further spread of the disease. But by artificially producing such conditions, the disease was kept at work for some time, but only on a very limited scale. Nor could it be spread, because in nature such artificial conditions could neither be produced nor maintained on any extensive scale. As many parts of the southern portion of this state were overrun with chinch-bugs, I thought that a good opportunity and an inviting field was presented to purposely spread a disease—an act not usually considered a very kind one to engage in, and one not to be recommended to physicians. This was exceedingly simple, as all that was necessary was to gather a number of the diseased bugs, put them in tight-fitting tin boxes and mail them to regions infested with chinch-bugs. Arrived at their destination, the contents of the boxes could be simply thrown in any field known to be infested with such bugs. This was done with specimens of the diseased bugs collected at the Experiment Station, and eighteen different places in Southern Minnesota were thus made centers of distribution for this disease. And, as it seems,with remarkably good results, as the disease has killed off the bugs to such an extent that careful search in a majority of places failed to produce a single living specimen, whilst the traces of the disease was found everywhere. The disease spread so rapidly that even corn growing near wheat-fields crowded with chinch-bugs was entirely protected, and no bugs had entered them in all the places visited by myself. But I am by no means satisfied that the disease was really introduced in this manner. Is it not possible that the disease was there already, unknown to anyone, and that I simply re-introduced its germs? The reason for this belief is based upon the fact that too large an area

was infested by the disease; too large to be readily accounted for by the short time in which the atmospheric conditions were—apparently—in its favor. But be this as it may; one thing is certain, viz.: The disease has been there, and consequently the spores of the fungus producing it are there also, and remain there, to act whenever the conditions are favorable; and I firmly believe that our farmers need not entertain any fears of chinch-bugs for the near future." The above statement was written late in the autumn of 1888, and subsequent events have shown that the belief then expressed became a fact. It might be added, that in the same autumn many thousands of circulars were mailed to farmers living in the region infested in that year with chinch-bugs. Several thousand replies were received, and by entering them upon a map of the state they clearly showed that for some reason or other the disease did execution only where introduced, and not in other places.

Besides the disease just mentioned, several others are found that are fatal to the chinch-bugs. One is a bacterial disease, thriving in the abdominal region of the bug. This disease seems to be less contagious than others, at least has as yet not given much promise that it might be utilized to destroy the insects upon a large scale. Bugs affected by it have usually a swollen abdomen, are weak and clumsy, so much so that if laid upon their back they are unable to reassume their proper position. After death the insects are not covered with a white dust composed of threads and spores, as is the case with other diseases caused by fungi.

The third fungus which causes the death of chinch-bugs is the White Fungas (*Sporotrichum globuliferum*). This fungus, though not strictly belonging to those that can only exist upon living insects, has been found to be the only one that can be manipulated with ease and success, as demonstrated again and again by the valuable and careful experiments made by Professors Snow, Forbes and others. Attacking by preference old and spent bugs, it will also attack healthy ones, in all stages of their growth, not even excepting the eggs. When conditions are favorable—i. e., when the bugs are weakened by wet weather—the increase of this fungus is exceedingly rapid and the disease caused by it sweeps over a large territory in a short time, killing the majority of the infesting army. The dried fungus can also be kept in tin boxes over winter, and is always ready to respond to our demands. As it matures its spores in a comparatively short time and in immense numbers, an artificial

increase may be very rapid. The disease caused by it would be a perfect remedy if all the conditions necessary to its spread in the infested fields could be controlled, which, however, is not possible. A bug infected by it shows symptoms similar to those attacked by the Entomophthora or Empusa already described. It becomes sluggish, does not like to move, changes somewhat in color, appears inflated, and is soon afterwards covered with an external white coat of fungus growth. This coat is so very dense that it hides more or less completely the dead host, thus differing greatly from the Entomophthora, where but comparatively few white threads are visible. Fig. 4 gives an idea of the appearance of this fungus enclosing a dead bug, while Fig. 3 shows that of the Entomophthora.

This short description of the three diseases now known to be fatal to chinch-bugs may suffice for the present time. Other diseases are also known, but they still require study and experiments to solve their history and habits. With these diseases we ought to be able to cope with the pest of our grain-fields, but at present we do not always succeed; nor can we expect to, simply because we cannot control the various necessary adjuncts to success, and consequently not too much confidence should be put upon any one of them. Future studies, experiments and experience may solve or lessen greatly the difficulties still in our path. Neither should we neglect to be always prepared; we should constantly be ready to utilize favorable climatic conditions and introduce such diseases, and should not wait for them to assist us, which they may or may not do. And as the spores of Sporotrichum can be kept for a long time without dying, can be increased both upon artificial cultures and upon the insects themselves, we should be failing in our duty to ourselves, to the community and to the whole state if we were not always ready to fight the enemy; in fact, an armed armistice should be the position held by us.

Methods of increasing the number of diseased bugs —Knowing the conditions under which fungi causing death to bugs thrive best, it is not very difficult to produce them artificially. We know that moisture and impaired health of the bugs are necessary. To produce the latter all that is necessary is to confine the more or less healthy bugs found in our fields to boxes made of wood—the infection boxes. Shutting off all the light, and forcing the bugs to exist in an atmosphere saturated with moisture, will give all the necessary conditions required by the fungus. If we take a shallow wooden box, six inches in depth, and not too large—say from three to four feet long and two feet wide—and cover the bottom with tightly pressed moist—not

wet—soil, we possess just what is needed. The bugs should, of course, be fed, and the sides of the box should be moistened from time to time, if it should become necessary. Chinch-bugs, loving the light, warmth and dryness, are not slow to be influenced by such unsuitable conditions as are prevailing in their prison, and soon become weaker in their vitality. If we now introduce a few diseased bugs, covered with the spores of the disease, the fungus causing it is surrounded by the necessary moisture and by bugs more or less weakened. The weaker ones, coming in contact with such spores during their anxious efforts to escape, will soon contract the disease, and after death become covered with a new crop of spores ready to further spread the disease. Many healthy bugs thus introducd into the infection box fail for a long time to contract the disease; in fact, we have sometimes raised a large number of young bugs to their pupal and even to their adult stage without having been able to make them diseased. But such cases are the exception and not the rule, as most of the bugs will before long show the effects of the infection, providing we have been careful to give the proper attention to the box. It is of course not necessary to introduce diseased bugs, as many persons seemed to think, as dead bugs are equally good, and better, being already covered with spores. Such an infection box will produce immense numbers of spores of the disease-giving fungi. The box should not be opened very often, since by doing so much of the moisture contained in the enclosed air will escape. A small sliding door in the top will facilitate the introduction of more prisoners. As soon as many bugs can be found that are covered with the fungus, they may be removed and other infection boxes can be started with them. When these boxes are working in a satisfactory way, most of the imprisoned bugs can be removed after two days and scattered in the fields infested with chinch-bugs. Those removed should be replaced with other bugs gathered in the field. In this manner everybody intending to utilize such diseases to fight the common enemy should be provided with an infection box in which he can produce all the spores he may require. It should be borne in mind, however, that cleanliness is here, as well as elsewhere, of great importance. The food provided for the still living bugs in the box, being surrounded by a moist atmosphere, so suitable for all kinds of molds, will soon decay, and therefore is apt to become moldy. This being the case, the food should be removed as soon as it is seen to commence to decay, as

decaying and rotting vegetable matter is sure to produce gases by no means of advantage to the fungi we are trying to produce. It is best to clean the boxes from time to time, because other enemies to our work will surely appear and give trouble. We should also not introduce too many bugs at the same time—not more than will fairly cover the surface of the soil. The infection boxes should be kept in the shade; if exposed to the hot rays of the sun we are apt to steam the prisoners, which, of course, will kill them, but not in the manner we wish to see them die. Nor should the boxes be kept in a cold cellar, as fungi of the kind desired require, besides moisture and weak bugs, sufficient warmth to develop rapidly. Perhaps it would be best to sink the whole box in a soil that is always well shaded. Of course many other methods will suggest themselves to the farmer, but he will do wisely to follow the directions here given, and not try to improve them, or even attempt to breed the disease in bottles, very wet inside, without containing food, tightly corked and exposed to the sun, as was done several times by some very smart persons who were furnished with diseased material. It is not simply dead bugs we wish to produce in the infection boxes, but diseased ones. Nor was it wise, in another case, to put the material received with the proper directions how to use it in a bottle that had contained castor-oil, or some other oil intended for a very different purpose. Many cases discovered last year showed that another "Comedy of Errors" might be written, based upon the manipulations of the chinch-bug diseases.

Other Enemies Besides Diseases.—It is strange how soon people, even after having lost their entire crops of cereals in former years by chinch-bugs, forget the appearance of that insect. Not infrequently we have been told by farmers that knew all about this pest that the bugs measured over half an inch in length or had from ten to fifty legs. This forgetfulness is also clearly shown by the large number of specimens of all kinds of insects received at the Experiment Station with the query: "Are these chinch-bugs?" Some of these specimens have not the least resemblance to them, but are as widely different from the genuine article as a horse is from a hen. The illustrations given in Figs. 5 to 8 show insects that are frequently mistaken for chinch-bugs. Figs. 9 to 12 show useful insects, or such as make it part of their business to assist us against the enemy by devouring the same. Illustrations, Figs. 5 to 8, show insects that are frequently mistaken for the true chinch-bugs, and which, in

FIG. 5. Piesma. After Riley.

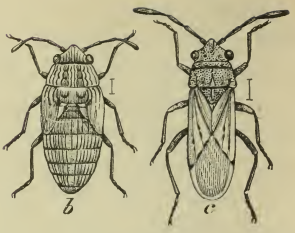


FIG. 7. False Chinch-Bug. After Riley.

FIG. 6. Negro-Bug. After Riley.

FIG. 8. Insidious Flower-Bug. After Riley.

consequence, have been frequently called "bogus chinch-bugs." These latter are by no means beneficial insects, yet they need not cause unnecessary alarm. The common names of all these insects are given below the illustrations. It seems that the chinch-bug occupies a position among insects shared by but few others—i. e., there is not a true parasitic insect that seems to enjoy the highly flavored bug.

When mentioning our friends among insects and other animals, we should not omit to state that many birds, reptiles, frogs and toads assist us materially against the enemy, and that we should protect our friends. It is a great shame that domineering man is so selfish! Birds like the Bob White and prairie chickens are killed on a large scale, simply because they are good to eat. But in pampering to our stomachs we forget that both birds, pressed by hunger during autumn, winter and early spring, make war upon the insects they may find hibernating. In fact, insects form the staple food for these birds, and consequently large numbers of chinch-bugs are

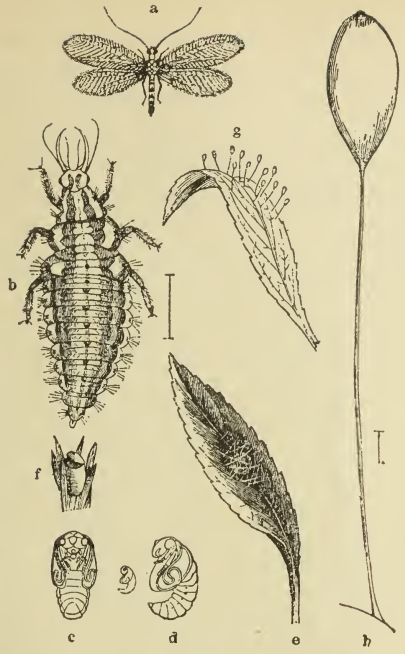
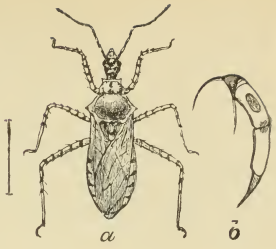


FIG. 10 Lace Wing.



Carnivorous Bug. After Riley.

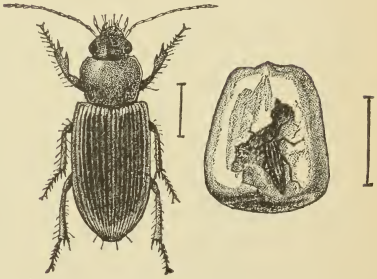


Fig. 11 Ground Beetle. From Div. of Entomology.

Fig. 12 Lady Bugs. From Div. of Entomology.

consumed. The red-winged blackbird, the cat bird, the brown thrush, the meadow lark, and several species of wrens, have been repeatedly observed to eat chinch-bugs, and even those of the above list that may appropriate some seeds and fruits not planted for them should be protected. Our domesticated fowls also eat chinch-bugs, but not all kinds and breeds act alike in this matter. Some chickens eat them greedily; others will not be tempted by them. The Guinea fowl and turkeys devour large numbers. Frogs and toads are also useful in chinch-bug years, and especially so the latter, which should always be protected.

What was done in 1894.—The climatic conditions which prevailed in 1894, and which were so highly favorable to chinch-bug increase, have already been mentioned. To illustrate them in a specific case, yet one not very different from the average condition that prevailed almost everywhere in Minnesota, the amount of rain and the temperature prevailing at Rochester is given in the following table, kindly prepared by Messrs. C. N. Ainslie and H. C. Butler, the former an ardent student of natural history and natural sciences:

1894.

MAY.	Wind.	Rainfall.	Temp.	JUNE.	Wind.	Rainfall.	Temp.	JULY.	Wind.	Rainfall.	Temp.	AUGUST.	Wind.	Rainfall.	Temp.	SEPTEMBER.	Wind.	Rainfall.	Temp.
1	N.W.	0.12	52 70	1	N.	0	42 73	1	N W.	0	68 82	1	N W	0	66-82	1	S. W.	0	47 81
2	S.E.	0	36-64	2	N.	0	46 80	2	N.W.	0	50 82	2	N.W.	0	53 84	2	S. W	0	64-92
3	S.	0	48 58	3	N.W.	0	52-78	3	N.W.	0	52-80	3	N.W.	0	40-66	3	S. W	0.01	69-89
4	S.	0	36-68	4	N.W.	0	44-72	4	N.W	0	52 74	4	S.	0	44-73	4	N. E	0	57 81
5	S.	2.04	48 63	5	N.	0	38 58	5	N.W	0	46 80	5	S.	0	50-78	5	S.	trac	56 80
6	W.	0	48-53	6	N.W.	0	32 70	6	N.	0	56 72	6	S.	0	55-85	6	S.	0	61 85
7	N.W	0	40-62	7	N.W	0.07	40 82	7	N.W.	0	42 78	7	S. W.	trace	59 87	7	S. E.	0	67 75
8	N.W.	0	38-72	8	S.	0	48 88	8	W.	0	48 86	8	W.	0	64-90	8	S. W.	0	56 81
9	N.W.	0	48 80	9	S.	0	58 84	9	S. W.	0	50-90	9	N.	0	60-97	9	W.	0	48-78
10	N.W.	0	48-56	10	S.	0	58 84	10	S. W.	0	56 90	10	S.	0 40	67-83	10	N.W.	0	44-80
11	S.	0	32 70	11	S.	0	60-90	11	S. W.	0	66 92	11	S.	0	64 85	11	N.W.	0	33-63
12	S.E.	0	48-80	12	S. W.	0	64 94	12	S. W.	0	70 92	12	S. W.	0	58-84	12	S.	0	37-68
13	S.E.	0	50 84	13	S. W.	0	64 96	13	S. W.	0	56-74	13	S. W.	0.15	58-83	13	S.E.	0	46-70
14	S.W.	0	64-84	14	S. W.	0	64 94	14	W.	0	50 80	14	S.	0	61 81	14	S. E.	0.25	52-71
15	S.	0.08	68-92	15	S. W.	trace	64 92	15	N.W	0	54-92	15	S. W.	0	53-82	15	S. W.	0	45 83
16	S.E.	0	62 82	16	S. W.	0	64 92	16	W.	0	60 94	16	S. E.	0	53-75	16	W.	0	49-71
17	S.E.	0 82	52 80	17	N. E.	0	72 68	17	S. W.	0	53-98	17	S.	0	57 83	17	W.	0	42-74
18	N.W.	0	36 50	18	E.	0	59-76	18	S.	0	64 98	18	W.	0	56-99	18	W.	0	28-64
19	N.W.	0	30-56	19	S. E.	0	52 78	19	S. W	0	68 94	19	W.	0	52-82	19	S. E.	0	48-72
20	N. E.	0	32 64	20	S. E.	0	66 90	20	N.W.	0	62 84	20	S.E.	0	59-85	20	W.	0	53-81
21	E.	0	40 58	21	W.	1.45	60-84	21	W.	0	46 86	21	S.	0	57-85	21	N. E.	0.66	47-66
22	N. E.	trace	46-56	22	S.	0	64 84	22	S. W.	0	54 92	22	S. W.	0	60-82	22	S. E.	0	47-75
23	N. E.	0	48 64	23	S. E.	0.78	64 78	23	S.	0	66 96	23	W.	0	65-88	23	N W.	0	44-69
24	N. E.	0	50 70	24	W.	1.08	64 80	24	N.	0	66 88	24	N.	0	61-91	24	W.	0	35-55
25	N.W.	0	42-76	25	S. E	0	58 80	25	S.	0	52 92	25	N. E.	0	57 87	25	S. E.	0	35-54
26	S.	0	48-84	26	S. E.	0	56-86	26	S.	0	72 102	26	N. E.	0	50-81	26	S. E.	0	52-62
27	N.W.	0	42 56	27	S. E.	0	59 84	27	N.W.	0	77 102	27	N.W.	0	58 83	27	S. E.	0	50 76
28	N.	0	32-64	28	W.	trace	62-84	28	N.W.	0	74 96	28	S. W.	0	58-88	28	S. W.	0.26	59-83
29	N W.	0	46-70	29	S.	0	56 89	29	W.	0	51 84	29	N.W.	0	60 90	29	S. W.	0	62 84
30	N.	0	40 60	30	S. E.	0	66 92	30	W.	0	59-89	30	W.	0	47-77	30	N.W.	0	40-79
31	N.	0	36-68					31	S.	0.03	69-89	31	W.	0	46-76				

Temperature figures furnished by Judge H. C. Butler, the others by Chas. N. Ainslie, both of Rochester, Minn.

Notwithstanding this almost unparalleled drouth, the crops of small grains were but little damaged, either by lack of moisture or by chinch-bugs; the ripening period of the plants was simply greatly shortened. Only in a few exceptional cases did crops suffer from both. Yet such favorable conditions must necessarily have vastly increased the number of chinch-bugs during that season, and the outlook for 1895 becomes gloomy indeed, if our fears should be realized. His Excellency, Governor Nelson, always willing to assist the

agricultural class of our citizens in such emergencies, and realizing fully the danger threatened by chinch-bugs, did all he possibly could by furnishing some means to start infection boxes. As there was no appropriation made for this important work, but a small sum of money could be expended, and not early enough in the season to fully test the value of the diseases discussed above. The County Commissioners of Olmsted, Blue Earth and Nicollet counties also assisted by appropriating some funds, and some of the owners of commercial mills helped all they could by furnishing help. Mr. Cole of Rochester and Mr. Hubbard of Mankato deserve the thanks of all farmers in their neighborhood for the interest taken in this work. A large amount of work was accomplished, and thousands of small tin boxes filled with diseased bugs were distributed to all farmers desiring them. A large number of reports showed that in many cases the disease worked well, even killing all the bugs infesting some fields. In many other cases the success was less apparent, and in still others none could be observed. Considering the phenomenally dry season, more could not be expected, and that in many fields the disease should have spread at all speaks well in favor of the white fungus disease, which was mainly employed.

Considerable harm has been caused by highly sensational articles in newspapers published during the last six or seven years, in regard to this method of killing chinch-bugs, which read as if the bugs could be killed by such diseases as if by magic, and this in a few days, or even hours. Nearly every farmer had read such articles, and many of the more uneducated ones based all expectations from the remedies applied by them upon such a disease instead of upon those dependent upon the habits of the insects—the only true remedies we possess at present. Many farmers actually expected that by throwing a pinch of the diseased bugs in a large field infested with bugs, these would—presto!—be found dead the next day. They did not realize that the introduction of a disease requires very careful work, and work that not every farmer can perform. To dispel any such illusions this bulletin has been prepared, and also to show how farmers must act to overcome the enemy. The results obtained by the experiments of last year are encouraging, yet no one should base all his hopes upon the introduction of such diseases alone, but should mainly depend upon the other remedies given, which are sufficient, if honestly and thoroughly applied. These latter can aways be depended upon, while the former may or may not

work, depending so much, as they do, upon conditions that cannot be controlled. Yet this does not mean that such experiments should be abandoned; on the contrary, they offer the only other hopes we possess of gaining the mastery over an insect like the chinch-bug. A private man cannot enter into these experiments, which are both expensive and tedious; but an agricultural state like Minnesota should always have the means ready to assist farmers if the opportunity offers. For this reason it is hoped that the legislature will see fit to appropriate a sufficient amount of money for investigations and experiments of this and similar character. "Forewarned is forearmed" is a proverb that should teach us a very valuable lesson.

UNIVERSITY OF MINNESOTA.

AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 38.

HORTICULTURAL DIVISION.

DECEMBER, 1894.

GARDEN TILLAGE AND IMPLEMENTS.

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA

ST. PAUL:
THE PIONEER PRESS CO.,
1895.

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GARDEN TILLAGE.

SAMUEL B. GREEN.

By the proper cultivation of the garden we accomplish three things: (1) The weeds are kept out so that they do not shade or take away valuable plant food and moisture from the plants which we desire to perfect. (2) The surface soil is brought into the best condition to resist drouth; that is, into the best condition for availing itself to the utmost of the stores of water in the subsoil and to prevent the evaporation of this water from the surface soil. (3) The stores of insoluble plant food are made soluble by the chemical action and fermentation, which are increased by loosening the soil, thereby letting in the air.

Keeping Out the Weeds.—The methods best adapted for keeping the weeds out of the garden are many and varied, and depend much upon the condition and kind of soil in which the weeds grow; upon the kind of crop and upon the habits of the weeds themselves. The most important step in making easy the prevention of weeds in the garden is the harrowing or other thorough cutivation of the land just before the planting of the seed, to kill the young weeds. If this is done thoroughly, the weeds do not have a better chance than the crop. If this is not done, the weeds will be ahead of the crop in growth, and if started even ever so little when the crop is planted, the result generally is that the crop is seriously overgrown by them before it is large enough to be cultivated. This is a common mistake, and is, perhaps, responsible for more failures in the garden than any other factor which enters into the consideration of this subject; and it is a very simple matter to prevent any trouble from this source if a little foresight is exercised.

Early Cultivation to Kill Weeds.—The next most important factor in the prevention of weeds in the garden is early cultivation. In the case of seeds that require a long time to germinate, it is an excellent plan to lightly rake over the land with an ordinary fine-toothed rake, even before the crop appears above the ground, providing the work is so carefully done as not to disturb the seeds.

When the seed is sown with a drill, the line of the row may be plainly seen even before the plants come up, thus making it easy to commence cultivating it in advance of the weeds. In case of such crops as carrots, onions, parsnips and beets, which are quite delicate when young, cultivation should begin with some hand garden cultivator, even if it is intended later on to cultivate with a horse, and the crop is planted with this purpose in view. Such close and careful work cannot be done with any horse implement now in use as with the best hand implements. With proper tools, the work may be done nearly as quickly by hand as by horse power, and far more perfectly when the plants are small. Careful early cultivation is of the utmost importance, since, if the weeds are removed when they are young, the work of weeding is very small. If allowed to remain until well rooted, their removal is often a very serious matter, and frequently, if neglected at this early stage, the weeds become so firmly established as to make it a question whether to remove them or plow under the whole crop; and often it is the part of wisdom to adopt the latter alternative. Aside from its effect in the prevention of weeds, early cultivation is of great value in breaking up the crust that packs firmly around the tender growing stems of plants, and which seriously inter feres with their growth. It is also, like all surface cultivation, of aid in the conservation of moisture in the soil. The effects of cultivation from this standpoint will be found referred to on page 186.

Importance of Not Allowing Weeds to Go to Seed.—A common source of weed infection is often found in the few weeds that are allowed to go to seed toward the end of the growing season in the maturing crop or after the crop has been gathered. To some farmers it often seems a small matter to allow a few plants of pig-weed, purslane, tumble weed and weeds of other kinds to go to seed in the garden, but absolute cleanliness should be the only rule in this particular, and it is by far the most economical in practice in the long run. It requires but little labor and saves much useless expense to destroy weeds that are going to seed. If the preventives for weeds here suggested are closely followed, hand weeding will be reduced to a minimum and will often be unnecessary with any crop.

Weed Seeds in Manure for the Garden.—While the discussion of the subject of manures for the garden is not the special object of this bulletin, yet some reference to the subject is quite necessary in considering the subject of weed eradication. The people of this state have not yet learned the great value of barnyard manure and

its proper preparation for best results in the soil. This is a subject of vast importance, and one that in the future will receive far more thought than at present. The manure applied to the garden is often coarse and contains many weed seeds, and is a fruitful source of weed infection. The manure intended for the garden that contains the seeds of weeds should be piled up and allowed to ferment until the whole mass is thoroughly rotted. By this means the seeds in it will be killed. But in order to rot manure to best advantage, it should be forked over occasionally when well warmed up by fermentation, and the whole turned over, with the outside of the pile thrown into the center. If dry, it should be watered enough to enable fermentation to continue, and to prevent "fire-fanging." It is seldom advisable to use fresh manure in the garden, and manure should only be applied in this condition when free from weeds, and then only for some late-maturing crops, in which case there will be time for it to rot before the crops need it. All early crops need well rotted manure, and require it in much larger quantities than do the late-maturing crops.

Plowing.—In Minnesota, where the summers are generally dry, the garden should always be plowed in the fall. It is seldom advisable to leave the plowing until spring in this climate, and if ever plowing is done in the spring, the plow should be run shallow. Deep spring plowing leaves too much of the upper soil loose and not sufficiently compact to enable the subsoil water to reach the surface roots.

Ridging the Land.—If the land is likely to be too wet in early spring for planting, sometimes it is good practice to turn several furrows back to back, and thus leave the land in ridges over winter.

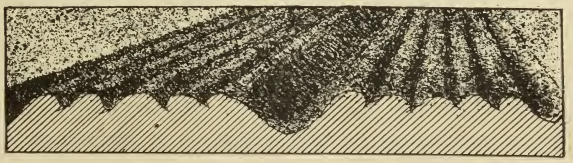


FIG. 1. Section showing ridged land in the winter.

If these ridges or "lands" are made fifteen to twenty feet wide, they may be dragged and planted in the spring without further plowing. For some crops it is often best to back-furrow out again in the spring, and thus leave the land level. This method of treatment

permits of working the land much earlier in the spring than it otherwise could be worked, if plowed flat. It leaves the soil in very good shape for the action of the frost on its particles during winter. For early crops on flat or heavy soils, it is a most desirable treatment. The objection to it is that if not turned back in the spring the dead furrows interfere with cultivation. If the land is plowed in the spring, it may be left too loose; but admitting these objections, even then there are often cases where this treatment would be very desirable. The soil for the garden should be worked to the depth of at least eight inches in order to be in the best condition for crops. On soils which have subsoil too compact, the subsoil plow may be used to advantage. It should be borne in mind in cultivating the garden that while the soil in it may be too loose, it cannot be too rich or too deep, nor can the subsoil, if not of too impervious a nature, be too compact.

General Cultivation of Garden Crops.—The methods to be pursued in the general cultivation of garden crops will vary somewhat, according to the soil, season and crop. However, it is very important to remember that the destruction of weeds is but a small part of the work of cultivation. The most important part is to so fit the soil that it may best withstand drouth. This is accomplished by frequent shallow cultivation during the period of growth. The first implements to use in the care of such crops as are generally cultivated by hand are those that work the soil to only a very slight depth, close to the plants. Such implements may be used just as the seedlings are breaking ground. As soon as the plants have gained some little strength, implements should be used that will go deeper, until a depth of two or three inches can be easily worked without endangering the safety of the crop by covering the plants with dirt. It is doubtful if any of our garden crops should ever be cultivated more than three inches deep, and it is very certain that many crops are injured by cultivating deeply very close to the plants, in which case the roots are cut off near their upper ends and thus wholly destroyed. Cultivation in a period of drouth results in forming a mulch or blanket of dry earth on the surface of the land, which prevents the moisture from passing into the atmosphere, and a rather shallow blanket, say two inches deep, accomplishes this purpose. A compact subsoil readily transmits the water upwards to the surface soil, in the same manner that a lamp wick carries the oil to the flame. At the surface the soil water

is prevented from evaporating by a blanket of loose earth, and is thus saved in the upper subsoil and lower and middle parts of the furrow slice for the roots of the crop; loose surface soil is a good non-conductor of water. During the growth of a crop, the surface of the ground should never be left long with a crust on it, but should be stirred after each rain or after artificially watering.

Cultivation to Develop Plant Food.—Nearly all land in the state contains immense quantities of plant food. Professor Snyder has shown that our average wheat-producing soils contain enough nitrogen to raise one hundred and twenty-five successive crops of wheat. But only a very little of this material is ever at one time in a condition in which the plant can take it up. Nearly all of it is insoluble. By chemical action and fermentation in the soil plant food is set free. This is increased and made more complete by admitting air into the soil; hence the reason for deep plowing in the fall, which allows the air and water to enter and thus develop the plant food. This, also, is an important fact to be kept in mind in cultivating land. Where the soil can be kept moist through the summer, deep spring plowing is an advantage, as it opens the soil to the air; but on account of the liability to drouth, the practice is a poor one for this state.

Garden Implements and Their Use.—It is very evident that mixed husbandry is to replace exclusive grain farming and cattle raising in Minnesota in the near future. With this change will come greater attention to the amenities of life. There will then be more demand for a variety of food, and consequently for the products of the garden. The importance of doing garden work by horse-power is so evident that it goes without saying. On every garden large enough to admit of it, horse labor should be used in preference to hand labor. As a rule, our farm gardens are too small to permit of this. One of the greatest hindrances to the successful cultivation of the garden is the common practice of so laying it out that a large amount of hand labor is necessarily involved in cultivating it. The farmers of Minnesota are justly proud of their achievement of almost entirely doing away with hand labor in the field, but in garden methods they still have very much to learn in this particular. The garden is a part of the farm that is often very unpopular, and I believe it is so largely from the fact that comparatively little effort is made to adapt modern methods to its management. Many of our vegetable crops can be grown without any hand labor whatever,

providing the soil is in good order to begin with, and free from weeds. The most important tool for the average horticulturist or gardener is a first-class horse cultivator. No pains should be spared to have the best implements, and then the most intelligent man in such matters on the place should run it. Too often the running of the cultivator is given to some young hand who has much more muscle than judgment, and his work is judged by the number of rows he goes over rather than by the care and completeness with which the work is done. It is best to go slow with the horse cultivator, for this means the saving of much hand labor. The best cultivators in use to-day are adjustable to various kinds of work, each of which they are capable of doing in an admirable manner. But, to get the best results from their use, they must be carefully studied and their attachments adapted to each special use. I want especially to insist that in order to get good work done by modern garden tools, they and the directions sent with them must be carefully studied. But even when horse labor is used as much as possible, there will always be a necessity for some hand work in such garden crops as onions, table beets and table carrots. These can probably be grown most cheaply in rows about fourteen inches apart, where the cultivation must be done largely by hand implements. These implements have reached a rare degree of perfection, and are wonderfully adapted for their purposes. The use of some of them has become a necessity in every well regulated garden. It is safe to say, that no one who cultivates a garden can afford to be without good hand and horse cultivators, with the modern attachments, and their more general use would make the farm garden more common and relieve it from being looked upon, as it often is, as being the most troublesome part of the farm. Hand seed sowers have also become necessary in gardens, and are so well made that they will sow almost any kind of garden seeds quickly and accurately as to quantity and depth of planting.

In order to use these hand and horse garden tools to the best advantage, the rows should be straight and long and the land cultivated flat. The rows to be cultivated by hand implements should be by themselves. It is important, also, to use short whiffletrees. The whiffletrees generally used for farm purposes are much too long for the best work, and their use prevents the proper use of modern cultivators. For ordinary garden purposes, these should not be over fourteen inches long, and when working in very narrow rows, one

may be used not over twelve inches long, providing the traces are protected from wearing the hair off the horse.

GARDEN IMPLEMENTS.

So many garden implements have been introduced within a few years that the Horticultural Division of the Experiment Station has made quite a collection, in order to study them. On the following pages will be found notes on such implements tried at the station as seemed to be particularly desirable.

The "Combination Drill and Cultivator," manufactured by Ames Plow Co., Boston, Mass., is arranged to use either one or two wheels, as may be preferred. (See Fig. 2.) The indicator is very simple in construction and is easily handled. The agitator is sure to keep the seed moving through constantly, unless clogged with some foreign material. The depth of sowing can be easily regulated. The wheel and coverer are simple and do the work required, viz: cover seeds

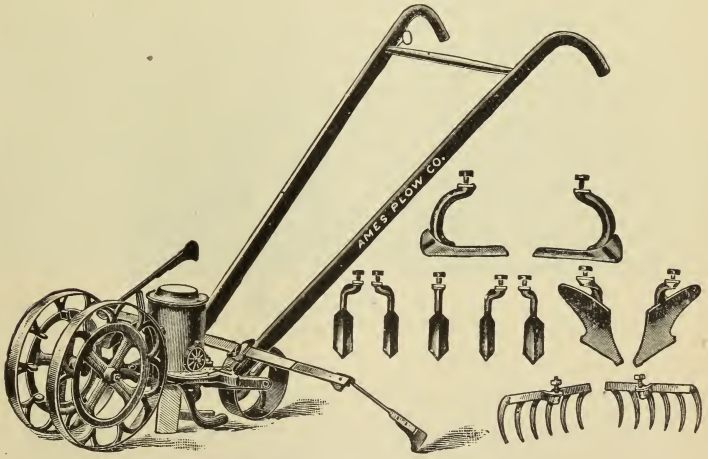


FIG. 2. Combination Drill and Cultivator.

and firm the soil over them. The marker is well adapted for giving a clean track for successive rows, and is easily changed to different widths. A convenient cut-off is provided to use when turning at the ends of the rows to prevent loss of seed. The change from the drill to cultivator, or vice versa, can be made very quickly. For working the soil it has hoes, plows, rakes and cultivator teeth of good shape and size. Being arranged to use either one or two wheels, the efficiency of the work that it can do is greatly increased. It can be

used successfully to open and close furrows. This feature is useful in planting seeds or plants two or four inches below the surface. The whole machine is put together in a workmanlike manner, and is made of good material. It is a very desirable implement for those who have a vegetable garden to cultivate. The machine is adapted to working on both sides of a single row with two wheels, or between the rows. This is also a convenient arrangement when sowing seed. The introducers, however, recommend for market gardeners, instead of this combined implement, separate implements, to

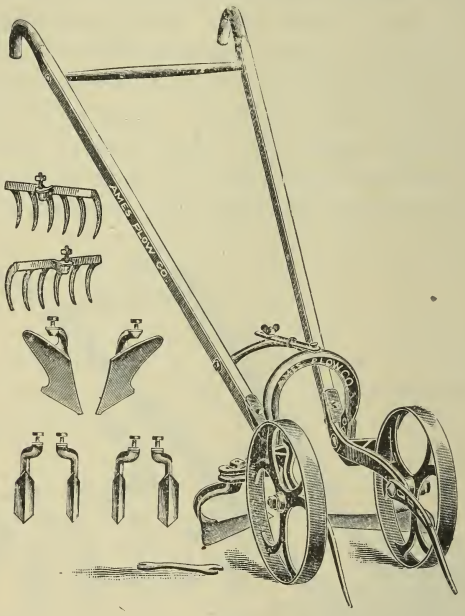


FIG. 3. New Universal Double-Wheel Hoe, Cultivator and Plow.

save the time of changes. They make the separate drill and separate cultivator, embodying the above features and others that cannot be included in a combination implement. This machine is shown closing furrows at (b) in the cover illustration. For further notice see page 23. List price, $13.50.

The "New Universal Hand Double-Wheel Hoe, Cultivator and Plow," shown in Fig. 3, is also made by the Ames Plow Co., Boston. This implement is of recent introduction and has all the latest improvements in this line. It is furnished with the usual tools, such as scuffle-hoes, cultivator plates, plows and leaf guards. A feature that

is very handy is the adjustable arch, by which the depth or angle of the cultivator teeth may be regulated. It can be used to work between rows or to straddle one row. The construction is excellent. A one-wheel cultivator closely resembling this, and which is very light and useful for cultivating between rows, is made by this same company. List price of double-wheel machine is $7.50, and single-wheel $6.

The A. H. Matthews Seed Drill has been used for many years at the University Farm and by many market gardeners. It has given good satisfaction as a safe and reliable seed sower. It is shown at No. 1 in Fig. 4.

New Model Seed Drill, made by the Bateman Manufacturing Co., Grenlock, N. J., is a very compact, light and strong machine. The forward wheel is of extra width, thus making it very easy to push through light soil. The agitator is an excellent arrangement and

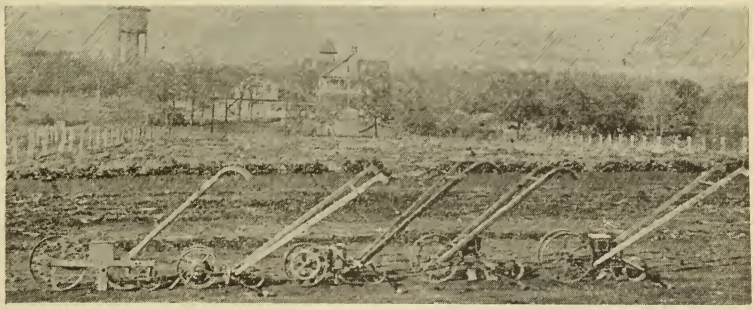


FIG. 4. 1—A. H. Matthews' Drill. 2—Planet Jr. Combined Drill. 3—Matthews' Combined Drill. 4—New Model Drill. 5—Planet Jr. Hill Dropping Garden Drill.

sure to keep the seed moving through the feed-hole in a regular stream. There is one feed-hole, the size of which is quickly changed by a simple and convenient device that permits of its being increased or diminished in size at pleasure. The coverer and the press-wheel are well adapted for covering seeds evenly and pressing the surface soil over them. The marker attachment for tracing lines for succeeding rows is well made and easily handled. This is an excellent garden drill, in every respect; list price, $9. This drill is shown at No. 4 in Fig. 4.

The Iron Age Horse Hoe (see Fig. 5), made by the Bateman Manufacturing Co., wherever tried has given good satisfaction. It is simple in construction and strong, and in every way a good imple-

ment for general work. The frame is of steel, and the standards and plates well suited for their purposes. The regular form has only five plates or shovels of medium width. A set of sweeps is provided for hilling. Two extra standards are provided, which may be used with narrow plates, forming a fine seven-tooth cultivator.

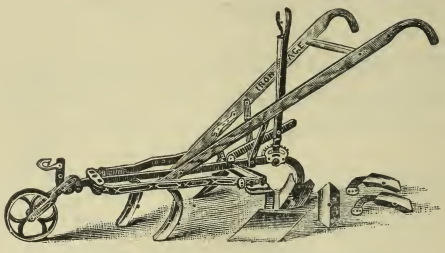


FIG. 5. Iron Age Horse Hoe.

It also has attachments for opening and closing furrows and all the requisites of a first-class horse hoe and cultivator. A lever controls the change of width, thus making it easy to work with it close up to the rows, even if they are not always parallel. List price, $9.50.

The Iron Age Combined Cultivator and Harrow. made by the Bateman Manufacturing Co., is a horse implement that is very efficient in forming a dust blanket in the garden during the dry summer months. It will also do admirable work when plants are small. It can be used very close to plants and to destroy any small weeds

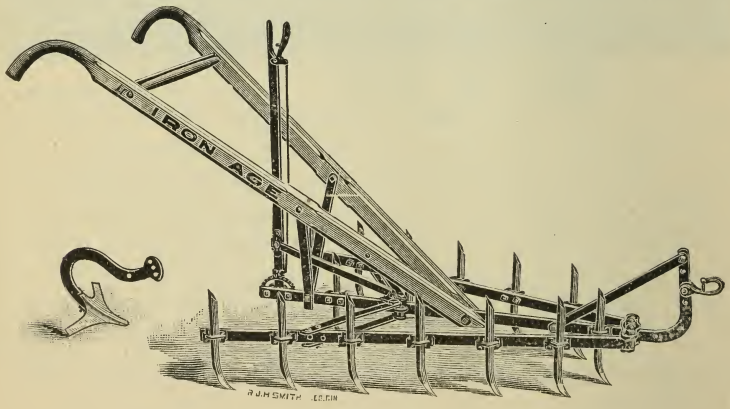


FIG. 6. Iron Age Combined Harrow and Cutivator.

that are near them. It has a lever expanding arrangement that works easily and quickly. The teeth are easily reversed, making either a straight or slanting tooth implement. The material and

construction is of the best. This is a favorite implement with many market gardeners. List price, $8.75. Fig. 6.

Gem of the Garden Hand Cultivator.—The Gem of the Garden Hand Cultivator is a very light but strong cultivator, made by the Bateman Manufacturing Co. It is furnished with cultivator teeth, scuffle-hoes and plows. Two wheels are provided, allowing it to be

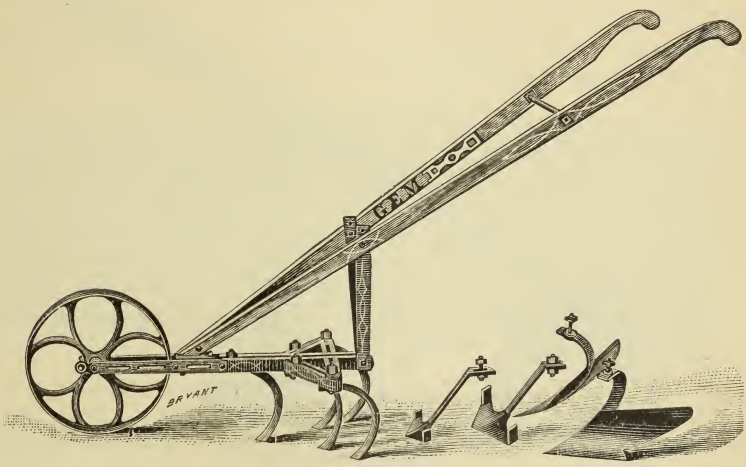


FIG. 7. Gem of the Garden Hand Cultivator.

used either as a straddle cultivator or simply as a one-wheel cultivator. The material and construction are of the best. All parts are made of steel. The extra parts furnished consist of a small landside plow and an onion harvester. List price, $6.50. Fig. 7.

The Jewel Double-Wheel Hoe is a very desirable hand implement for close cultivation of garden crops. It is made to be used as a straddle hoe or between the rows only. It is well adapted for the light, close cultivation that is necessary when plants are young and just starting into growth, or for the deeper and more thorough cultivation during the summer months. It is of light construction, but strong and well made and compares favorably with the implements of other makers designed for the same purpose. List price, $6. Made by Bateman Manufacturing Co. Fig. 8.

The Cover Illustration is reproduced from a photograph of work done in opening and closing furrows by the Planet Jr. and Matthews' combined garden cultivators. At (a) is shown the Planet

NOTE. The Bateman Manufacturing Co. refers correspondents to their Northwestern agents, Lindsay Bros., Minneapolis, Minn.

Jr. implement, which has a one-moldboard plow at work opening furrows. At (b) is shown the Matthews combined garden cultivator at work closing furrows, for which purpose it has two one-moldboard plows, which may be reversed when used for opening furrows.

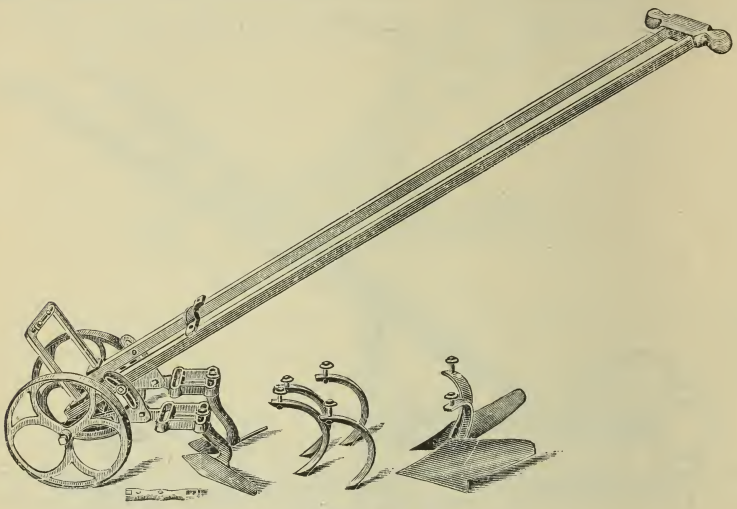


FIG. 8. Jewel Double Wheel Hoe.

The Buckley Cultivator manufactured by R. C. Buckley, Peoria, Ill., is designed to give extra leverage by having the wheel thirty inches in diameter. This also gives a steadiness not possible in a machine with smaller wheels. The various attachments are placed

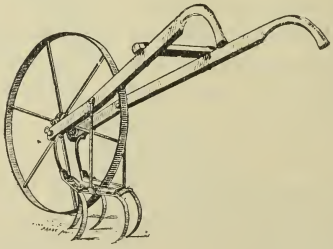
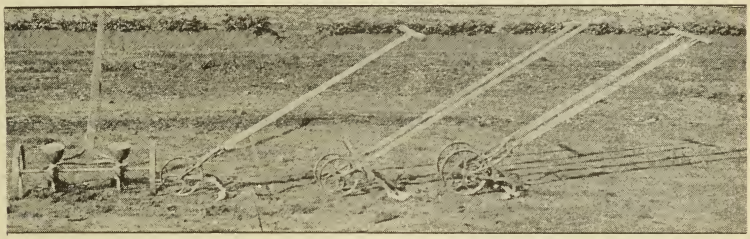


FIG. 9. Buckley Cultivator.

in holes arranged around the frame, almost under the axle of the wheel. The material used in its construction is good. It is especially useful in heavy land for loosening the soil when it bakes hard in summer. It is the most powerful hand garden implement known. Market gardeners will find it very desirable. List price, $8. Fig. 9.

The Universal No. 3 Straddle Hoe is a very light and simple hoe, capable of doing good work when weeds are small and land moderately fine. The blades are nicely adapted for cutting weeds under the surface of the land and to scour well. The manufacturers recommend this implement for use when onions are small and afterwards the use of the Sherwood No. 3 Union Hoe. List price $5. It is shown at No. 3 in Fig. 10, and is manufactured by C. O. Jelliff & Co., Southport, Conn.

The Sherwood No. 3 Union Hoe is designed to be used as a general hand cultivator for garden crops. It is light and strong, and the material is of the best. Hoes of good shape, designed to cut under the surface of the soil. A novel feature is the addition of two small disks which can be set at any angle so as to loosen the soil in the rows, like the disks of a disk-harrow. An onion puller attachment is manufactured for this implement. It has a curved hoe running under the onions and a mold-board behind, which rolls the onions to one side and thus turns two rows together. It does its work very well. List price, $7. Shown at No. 4, Fig. 10. Manufactured by C. O. Jelliff & Co.



1 2 3 4

FIG 10. Hand Garden Implements' Manufactured by C. O. Jelliff & Co. 1—Universal Onion Drill. 2—Universal One Blade Hoe. 3—Universal No. 3. Straddle Hoe. 4—Sherwood No. 3 Union Hoe

Universal One-Blade Hoe is a very useful and efficient one-blade hoe for close work in the garden. The blades may be of any length. Its special use is to keep the surface of the land free from weeds. It does not work the soil except on the surface. List price $2.75. Shown at No. 2 in Fig. 10. Manufactured by C. O. Jelliff & Co.

The Universal Onion Drill is very simple in construction, of excellent workmanship and light in weight but strong enough for general work. It is designed to sow two rows at a time. Two styles of this machine are manufactured, one sowing twelve inches apart and the other fourteen inches. Two seed hoppers are on the axle, and the seed is forced out by small wheels which turn on the

axles, thus making it sure to drop the seeds very accurately and evenly. The track of the outer wheel is the mark for the inside wheel to follow in returning. With land in reasonably good condition, this machine will do rapid and excellent work. Large onion growers will find this seeder a very desirable implement. It is designed especially to sow onion seed, and is not intended for general purposes. List price for the twelve-inch machine is $8; fourteen-inch, $10. This drill is shown at No. 1 in Fig. 10, and is manufactured by C. O. Jelliff & Co.

The McGee Cultivator is a light, strong and efficient hand cultivator. The handles are held apart with a spring, which makes it very convenient to go close to plants, or to keep away from the row, as may be desired, without any change of bolt or other appliance. The arch is very high, so as to allow it to pass over tall plants without breaking the tops. The tools accompanying the machine are well adapted to cut out small weeds, to keep soil well stirred, etc. It is also provided with an onion puller, which passes under the row, lifting the onions and dropping them again in the rear. The materials used in its construction are very good. It is manufactured by Deere & Mausur Co., Moline, Ill. List price, $5.

The Planet Jr. Hill-Dropping Garden Drill differs from any other drill on the market in its arrangement for sowing the seed in hills, It is of excellent workmanship, and will do everything that the manufacturers claim for it. We quote from their catalogue as follows: "Until recently there was no such thing as a hill-dropping seeder, most modern drills sowing seed only in a continuous row. The demand for a machine that could be adjusted to plant in hills has been urgent. If seed is drilled and the plants thinned out, it is often hard to find a strong plant at the right point, even with thick sowing; but with hill-planted seed you are almost sure to find two or three good plants at the exact spot where one is wanted. This is accomplished, too, with far less seed. Thus, with great saving of labor, time and seed, a far more regular crop is produced. This is often of great importance, as in sugar beet culture. This drill will sow in a continuous row, in the ordinary way, with the greatest regularity; but its distinctive feature is that it will also drop neatly in hills, either four, six, eight, twelve or twenty-four inches apart. It opens the furrow, plants, covers, rolls down and makes a mark for

NOTE. Northrup, Braslan & Goodwin Co., Minneapolis, Minnesota, are Northwestern agents for C. O. Jelliff & Co.'s implements.

the next row, all at one operation. The hopper holds two quarts. The wheels are fifteen inches high. It is changed in a moment from hill-dropping to drill work by simply hooking up the 'cut-off,' and is changed back again instantly by releasing the cut-off. The flow of seed is stopped or started instantly by a single movement of the fore-finger, without stopping or taking the hand from the handle. This is so easily done that not one hill need be missed in starting or stopping. The drill has a force feed; a peculiarly formed rubber double screw works over a diamond-shaped opening in the bottom of the hopper. While it sows with perfect regularity, the rubber feed wheel, revolving within a brass cylindrical shield, cannot injure delicate seeds, such as radish, cabbage, etc. It sows equally well, whether the hopper is full or contains only a paper of seed. The setting is quickly and accurately done for the different seeds by a simple thumb-screw. An index plate, with the names of the principal seeds, is placed at the top of the right handle, and the screw is turned until the indicator stands opposite the name of the one to be sown." List price, $12.

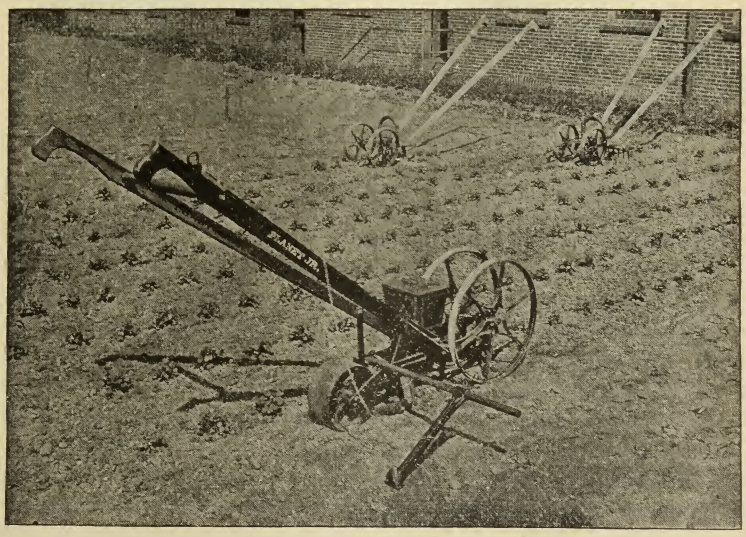


FIG. 11. Plants Growing as Sown by the Planet Jr., Hill Dropping Garden Drill.

The Planet Jr., Combined Drill and Cultivator has for many years been very popular and is certainly an excellent combination for the home garden and for small vegetable gardens generally. The

manufacturers do not offer it as the most desirable implement for market gardeners, but recommend to those cultivating any considerable amount of land the use of separate drills and cultivators. It is well made, low in price, and does excellent work. This implement has all the attachments for the most successful cultivation of garden plants that are commonly grown in narrow rows. It may be

FIG. 12. Planet Jr. Combined Drill and Cultivator.

used when the plants are under six inches high to work the soil on both sides of the row at one operation. It also does the best of work when used between the rows. It will sow any of our common garden seeds evenly and well, covering at an even depth, and will cultivate the plants as perfectly as any garden cultivator. It may also be used to open or cover furrows. The changes from drill to cultivator, or vice versa, are quickly and easily made. List price $12. This machine is shown at (a) in cover illustration, and in Fig. 12.

The Planet Jr. Double Wheel Cultivator is made for the cultivation of the soil between two rows, or on both sides of a single row at one operation. The attachments are very complete and include a set of curved-point hoes, rakes for leveling land, plows, wide and narrow cultivator teeth and leaf guards. The attachments are made to fit in long slots behind the wheels, thus making it easy to change width between them. The changes in attachments are

easily and quickly made. It can be used as a cultivator on both sides of the row until plants are about eighteen inches high. This is the style of tool most desirable for general use by market gardeners. The materials and construction are of the very best. These machines are also furnished with an onion-puller attachment. List price, $8. Fig. 13.

The Planet Jr. Single Wheel Hoe, Cultivator, Rake and Plow combined is designed to work between the rows, and will do admirable work. It has the same attachments as the Double-Wheel Culti-

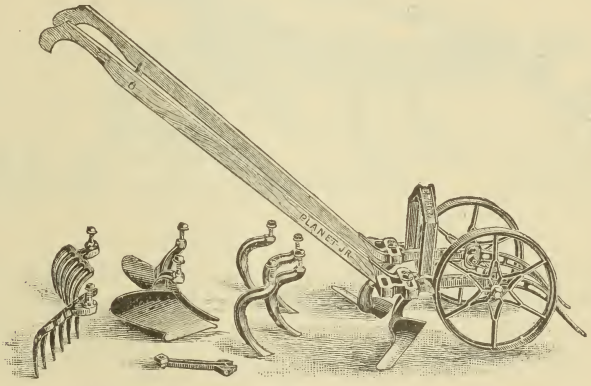


FIG. 13. Planet Jr. Double-Wheel Cultivator.

vator. It can be used on both sides of the row, but is not as desirable for such a purpose. It is strong in construction and a very desirable implement. List price, $5.

The Planet Jr. Horse Hoe has made a very favorable record wherever it has been tried. The construction is so complete that it can be used for almost all kinds of horse work in the garden. It will open and close furrows for potatoes, will do good work as a cultivator, and will draw the soil from or throw it toward plants. The attachments comprise sets of narrow cultivator teeth, wings for pushing the soil to one side or to carry it to the center between the rows, and sweeps for shallow cultivation. A useful attachment is a pulverizer or rake to level the surface in the rear. Two extra side-bars are provided, which allow the use of nine narrow plates instead of five. Two levers are attached, one of which regulates the depth and the other the width. The list price is $12. Fig. 14.

The Planet Jr. Twelve-Tooth Cultivator and Pulverizer is intended for fine horse cultivation, either deep or shallow, and for

working among small plants. In the hands of a careful man, this cultivator will work the soil in a field of small cabbages or other

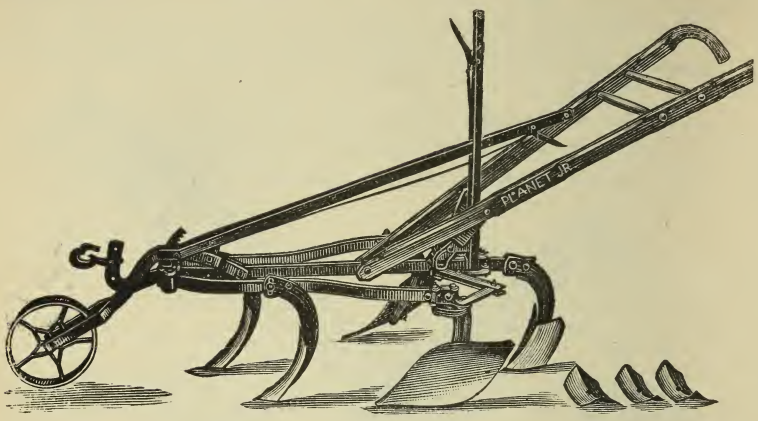


FIG. 14. Planet Jr., Horse Hoe.

small plants so that no land will be seen that has not been stirred, and yet the plants will not be injured. The teeth plates are about one inch in width, and are set so as not to clog easily. The depth and the width of cultivation are easily and quickly controlled by

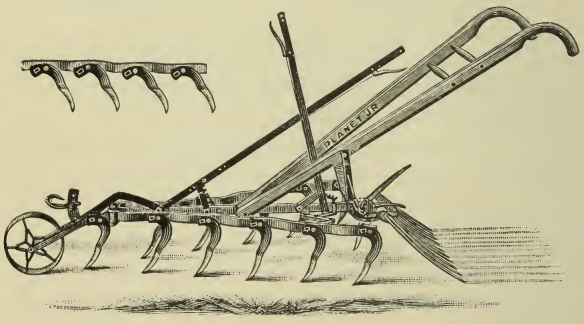


FIG. 15. Planet Jr. Twelve-Tooth Cultivator and Pulverizer.

levers. The pulverizer attachment is readily put on, and leaves the surface of the soil fine and smooth. The teeth can be changed so as to work as a slant-tooth cultivator. I consider this an especially valuable tool for keeping a dust blanket on the surface of the land during the dry weather of summer. List price, $12.50. Fig. 15.

The Planet Jr. Implements are manufactured by S. L. Allen & Co., Philadelphia, Pa., who refer correspondents to their agents, Lindsay Bros., Minneapolis, Minn.

Scuffle Attachments for Hand Garden Cultivators—Fig. 16 shows two sets of implements designed to be attached to the ordinary wheel cultivators, which will work close up to young plants so as to cut off the weeds just under the surface of the soil. They were de-

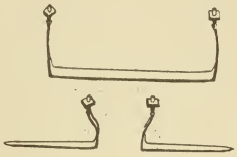


FIG. 16. Home-Made Attachments for Garden Cultivator.

signed by Mr. William Mackintosh, a market gardener of Langdon, Minn., and will be found very useful in many places. They can be made out of tool steel by any good blacksmith. The length of blades may be made to suit work.

The Scuffle Hoe, shown in Fig. 17, is an excellent old-fashioned implement for shallow cultivation, such as is needed in spring in the garden. Besides, it is so very cheap and simple that it can be made by any handy blacksmith. It cannot be recommended to take

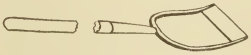


FIG. 17. Scuffle Hoe.

the place of the improved wheel hoes for large gardens, but in a small garden it may be used for the work of shallow cultivation to good advantage. It does not work the soil deep enough for the best summer cultivation.

UNIVERSITY OF MINNESOTA.

AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 39.

HORTICULTURAL DIVISION.

DECEMBER, 1894.

POTATOES,—VARIETY TESTS, POTATO SCAB, BLIGHT AND INTERNAL BROWN ROT; TOMATOES,—VARIETY TESTS, TRAINING; STRAWBERRIES,—VARIETY TESTS; APPLE-TREE SUN-SCALD; RASPBERRIES,—VARIETY TESTS, CANE RUST.

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.

ST. PAUL:
THE PIONEER PRESS CO.,
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☞ The Bulletins of this Station are mailed free to all residents of the state who make application for them.

EXPERIMENTS WITH POTATOES.

SAMUEL B. GREEN.

Experiments with potatoes in 1894 consisted largely in the trials of forty varieties at the Experiment Station and a duplication of the same varieties at Bethel, Anoka county. Trials have also been made to determine the value of various fungicides as preventives of scab and rust of potatoes. On account of the very dry season, the yield of potatoes was very light at the University Farm and at Bethel, yet the results are not without interest to the potato growers of the state. The soil in which the potatoes were grown at the University Farm is a light, somewhat sandy, loam, in a very good state of cultivation. So far as known, however, it had never grown potatoes before. The land used for the experiment at Bethel had produced two crops of potatoes. It is sandy loam, and is representative of much of the best potato land of that section, and was selected on that account. The seed in each experiment was cut to two good eyes, to a rather large piece of potato, and was planted about the 25th of May, in rows three feet apart, with sixteen inches between the pieces of seed in the row, and was covered four inches deep. The rows were 150 feet long, and, with few exceptions, each variety occupied one row. As soon as the potato tops commenced to show, the land was dragged with a slanting-tooth harrow, to loosen the soil around the plants and to kill the weeds which had started. They were dragged also a little later and again when the tops were about four inches high. Further cultivation consisted of loosening the soil between the rows with a one-horse cultivator. This same tool was also used to throw a little earth toward the hills, but the crop was not hilled much. The land was kept nearly flat. This method of cultivation is perhaps as good as any for the general cultivation of potatoes in this state.

When the early varieties were beginning to mature they were examined every few days to note when they were of marketable size. After this time most of the other varieties were examined at frequent intervals, with the same purpose in view. The notes relating to this matter will be found in the seventh column of Table LXV.

TABLE LXV.—Potatoes,—Variety Tests. University Farm, 1894.

	Yield in Pounds of 150 Feet of Row.			Yield in Bushels per Acre.			Date when ready for market.
	Marketable.	Unmarketable.	Total.	Marketable.	Unmarketable.	Total.	
Acme Seedling	36	7	43	58	11	69	July 25.
American Wonder	23	16	39	37	26	63	Late.
Arizona	25	16	41	40	25½	65½	Medium.
Beauty of Hebron	31½	14½	46	51	23½	74½	Aug. 5.
Burbanks	27¼	12¾	40	40	24	64	Late.
Delaware	17½	12½	30	29	20	49	Aug. 22.
Early Ohio	45	11½	56½	73	19	92	July 25.
Early Oxford	25	14	39	40	22	62	Aug. 5.
Early Rose	34	19	53	44	30½	74½	Aug. 5.
Freeman (from J. C. Vaughan)	13½	25½	39	22	41½	63½	Early.
Freeman (from Mr. Freeman)	9½	19½	29	15	30	45	Early.
Freeman (from De Cou & Co.)	10½	20	30½	17	32	49	Early.
Ideal	25	6½	31½	44	14	58	Aug. 8.
I. X. L.	31¼	10	41½	51	16	67	Aug. 1.
Lee's Favorite	35½	21½	57	49	33	82	Late.
Maggie Murphy	48	6½	54½	77½	10½	88	Late.
No. 5	42	7	49	67	11	78½	Late.
Ohio Jr.	42	7	49	67½	11	78½	Aug. 1.
Polaris (?)	28½	29	57½	46	34	80	Aug. 16.
Racquet Seedling	..	..	..	..	..	..	Early.
Reed's Eighty-six	28½	21	49½	46	33	79	Aug. 1.
Red Ohio	25	15	40	40	24	64	July 25.
Rural New Yorker, No. 2	26	9	35	42	14½	56½	Late.
Snowflake	44½	7½	52	72	12	84	Late.
Summit	7½	27	34½	12	44	56	Medium.
Thorburn	19	8½	27½	31	14	45	Aug. 8.
Vaughan	40	17	57	65	11¼	76½	July 25.
Vick's Champion	33	10¼	43½	53	17	70	Aug. 22.
Western Red	33	5½	38½	53	9	62	Late.
White Prolific	25	18⅛	43½	40	29	69	Late.
World's Fair	8	8½	16⅛	13	14	27	Late.

TABLE LXVI.—Potatoes,—Variety Tests. Bethel, Minn, 1894.

	Yield in Pounds of 150 Feet of Row.			Yield in Bushels per Acre.		
	Marketable.	Unmarketable.	Total.	Marketable.	Unmarketable.	Total.
Acme Seedling	50½	24½	75	81½	39½	121
American Wonder	40	14	54	64½	22½	87
Arizona	47	24	71	76	39	115
Beauty of Hebron	50	19	69	80½	30½	111
Burbanks	34	17	51	55	27	82
Delaware	43	16	59	68½	26	94½
Early Ohio	52	17	69	84	27	111
Early Oxford	61	19	80	98	30½	118½
Early Rose (true)	40	29	69	64½	46½	111
Freeman (from J. C. Vaughan)	..	22	22	..	35½	35½
Great Northern	44	22	66	70	35½	105½
Ideal	50½	14½	65	81½	23½	105
Late Rose (?)	60	20	80	97	32	129
Lee's Favorite	40	21	61	64½	34	98½
Maggie Murphy	12	11	23	19	17½	36½
Ohio Jr.	50½	13½	64	81	22	103
Polaris (?)	63	28	91	101½	45	146½
Reed's Eighty-six	49	12	61	79	19	98
Red Ohio	..	20	20	..	32	32
Rural New Yorker, No. 2	14	10	24	22½	16	38½
Snowflake	48	28	76	77½	45	122½
Summit	48½	16	64½	78	26	104
Vaughan	59½	21½	81	96	34½	130½
Vick's Champion	48	13	61	77½	21	98½
Victor White	61	14	75	98	22½	120½
Western Red	18	10	28	29	16	45
White Prolific	48	22	70	77½	35½	113
World's Fair	..	22½	22½	..	36	36

It will be noticed by any one who carefully examines the foregoing tables that the early varieties produced far more marketable potatoes than the late or medium kinds. This was undoubtedly due to the fact that the more productive kinds made their growth during the early part of the season, when the conditions were most favorable, while the late varieties suffered more severely from the excessively dry, hot weather which prevailed during the time when they should have been in their most active period of growth. Most of the later kinds seemed to have been very sensitive to any condition affecting their growth. Many of the tubers from these kinds were on this account so rough and ill-shaped as to be unmarketable. Some single specimens showed at least three distinct periods of growth. The late kinds set a larger number of potatoes than the early varieties, but these could not mature on account of the excessively dry weather.

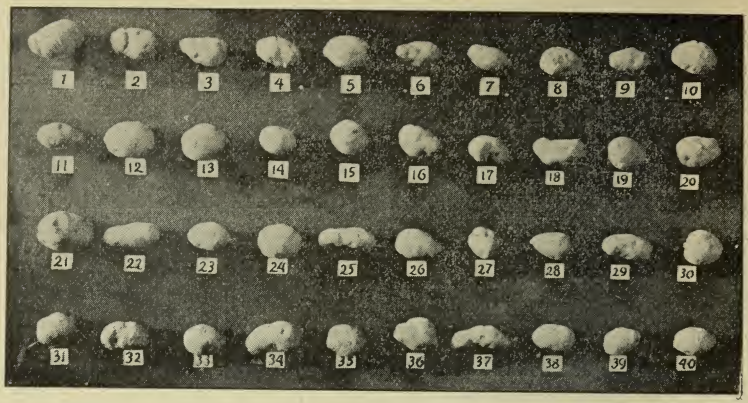

FIG. 1. Typical Tubers of Varieties Numbered Below, as Grown in 1894.

1. Acme Seedling.
2. American Wonder.
3. Arizona.
4. Beauty of Hebron.
5. Carman No. 1.
6. Colossal.
7. Crown Jewel.
8. Delaware.
9. Early Everett.
10. Early Ohio.
11. Early Oxford.
12. Early Rose.
13. Empire State.
14. Freeman.
15. Great Northern.
16. Green Mountain.
17. Heavy Weight.
18. Ideal.
19. Late Rose (?).
20. Lee's Favorite.
21. Maggie Murphy.
22. No. 5.
23. Ohio Junior.
24. Polaris. (?)
25. Racquet Seedling.
26. Reed's Eighty-Six.
27. Red Ohio.
28. Rural New Yorker, No. 2.
29. Six Weeks' Market.
30. Snowflake.
31. Summit.
32. Thorburn.
33. Vaughan.
34. Vick's Champion.
35. Victor White.
36. Western Red.
37. White Prolific.
38. World's Fair.
39. Burbanks.
40. I. X. L.

NOTES ON VARIETIES OF POTATOES.

Acme Seedling.—Form, oblong, short, thick; eyes, medium to large; color, pink; skin, a little rough. Very early; ready for market July 25.

American Wonder.—Form, flat oblong; eyes, many, prominent near stem end and hollow near seed end; skin, smooth, white.

Arizona.—Form, oblong, somewhat pointed; eyes, shallow; skin smooth and white.

Carman No. 1.—Form, broad oval, flattened; eyes, few, medium in size; skin, nearly white.

Delaware.—Form, short oval; eyes, few and of medium depth skin, white, very finely netted.

Early Oxford.—Form, round oval; eyes, large and shallow; skin, smooth and nearly white.

Freeman.—Form, round oval; eyes, few and very shallow; color creamy white; skin, finely netted.

Great Northern.—Form, round; eyes, small and shallow; color nearly white; skin, netted.

Green Mountain.—Form, rather long; eyes few and shallow color, nearly white; skin, netted.

Ideal.—Form, long, slightly irregular; color, light red; eyes, few, small and of medium depth.

Late Rose (?).—Form, round oval; eyes, few and shallow; skin heavily netted. (Probably some mistake in the name.)

Lee's Favorite.—Form, irregulular oblong; color, white; eyes, large some of them deep, mostly shallow; skin, somewhat netted.

Maggie Murphy.—Form, broadly oval; light pink in color; skin, netted; eyes, few, some of them very shallow, others large and rather deep.

Ohio Jr.—Form oblong, somewhat pointed; eyes, many and rather prominent; skin, a little rough; color, pink.

Racquet Seedling.—Form, long cylindrical; color, snowy white, eyes, many and of medium depth; skin, slightly rough.

Reed's Eighty-Six.—Form, oblong to round; color, light rose; eyes, medium in number and depth; skin, netted.

Red Ohio.—Small to medium in size; red in color; form, usually round; eyes, large and medium in depth.

Rural New Yorker, No. 2.—Form, oblong, usually pointed; eyes; shallow and few; skin, smooth or slightly netted and white.

Snowflake.—Form, oblong; eyes, few and shallow; skin, netted, white.

Thorburn.—Form, oblong, somewhat resembles Beauty of Hebron, from which it is a seedling; eyes, medium in number and rather shallow; skin, nearly white; flesh, snowy white.

Vaughan.—Form, oblong, has a tendency to become pointed on seed, end this year; eyes, rather large but shallow; skin, nearly white and heavily netted.

Vick's Champion.—Form, rather long, slightly cubical; eyes, large and shallow; skin, white and nearly smooth.

Victor White.—Form, compact, oval ends flattened; eyes, few and shallow; skin, nearly white and a trifle netted.

White Prolific.—Form, rather long and cylindrical; skin, smooth, and white; eyes, many but small and shallow.

World's Fair.—Form, oval; eyes, shallow; skin, very finely netted, yellowish white; flesh, white.

Western Red.—Very large and irregular in form, usually oblong; skin, light red.

I. X. L. —Form, oblong, cylindrical, has a tendency to be pointed; eyes, large and prominent; skin, light red, somewhat resembling the Early Ohio.

POTATO SCAB.

The seed tubers of nearly all the varieties of potatoes planted at the University Farm in 1894 were to some extent marked with the fungus disease commonly known as potato scab. All kinds were treated with corrosive sublimate, as recommended in Bulletin No. 32, with the result that the crop was almost entirely free from any appearance of scab, while a few that were not treated were quite rough from the work of the scab fungus. This treatment seems to have been so thoroughly tried that it is no longer a doubtful matter, but it is a step in the cultivation of the potato that growers cannot afford to overlook. The method of treatment adopted this year was as follows: Two ounces of powdered corrosive sublimate was dissolved in a wooden bucket, and when all had dissolved the liquid was poured into fourteen gallons of water contained in a barrel and thoroughly stirred. The potatoes were put in sacks and were thus soaked in the corrosive sublimate solution for one and one-half hours. They were then taken out, dried and cut into pieces for planting. It was found that soaking them for two hours did not injure the growth in any way, but that one and one-half hours was sufficient time to kill the scab fungus where the tubers were only slightly affected. In one case where the tubers were excessively covered with the scabs, so that even the eyes could not be made out, soaking for one and one-half hours was not long enough to kill the scab fungus. I would recommend that, where the potatoes are excessively rough, they be soaked in the corrosive sublimate solution for at least two hours. But potatoes that are excessively scabby should, if possible, be avoided for planting purposes. The expense of the treatment above referred to for the prevention of scab should never exceed $1 per acre, including the cost of the materials and the labor of treatment.

As the peculiarities of this disease, which we commonly call "scab," are not as well known as they should be, I give below a short abstract from Bulletin No. 32 of this station, in which its peculiarities and characteristics are treated at considerable length:

"(1) Scab of potatoes is caused by a fungus plant working in the surface of the potato. The germs of it are very abundant and live for many years in the soil and also over winter on the potatoes. If these germs are fed to stock, they undoubtedly grow in the manure, and the use of such manure may often be a cause of infection. Also, they may be spread in the soil by the natural drainage and land receiving the drainage from infected fields may become infected even without ever having potatoes on them.

"(2) Scabby seed, when planted on new or old potato land, will generally produce a scabby crop, but the amount of the disease will generally be much more on the old than on the new land.

"(3) Perfectly clean seed planted on land which is free from scab fungus will always and in any season produce a crop of smooth, clean potatoes, no matter what the character of the land. But seed potatoes apparently clean may have the germs of the scab fungus on their surface. This is often the case where they have been sorted out from a lot that is somewhat infected with the scab. In this latter case, the tubers should, at least, be thoroughly washed in running water, to remove any germs that may be present, or, what is better yet, be treated with corrosive sublimate (mercuric bichloride), as recommended.

"(4) Land infected by the germs of this disease will produce a more or less scabby crop, no matter how clean and smooth the seed used.

"(5) Scabby potatoes should be dug as soon as mature, since the scab fungus continues to grow on the potatoes as long as they are in the ground.

"(6) Scabby potatoes may be safely used for seed, provided they are first treated with corrosive sublimate, as recommended. The cost of this treatment is a mere trifle, not exceeding one cent a gallon for the solution used."

BLIGHT OF POTATOES.

In a previous bulletin the results of the treatment of blight of potatoes by Bordeaux mixture were given at considerable length. This season the treatment gave but very slight returns, and although

it increased the yield, it was such a small increase that it did not pay for the labor involved in the application of the poisoned solution. The most probable reason for the slight returns from the treatment given this year is, I think, to be found in the fact that the potato seed was treated with corrosive sublimate before planting and was planted on new land, not near where potatoes had been grown for many years, consequently the disease was not present to a serious extent. The excessively dry season was also unfavorable to the growth of diseases. However, our experience for several previous years, and the experience of many others elsewhere, make it certain that in seasons favorable to the growth of blight, it will pay well to apply Bordeaux mixture to the potato tops in those locations where this disease is commonly destructive. Bordeaux mixture is made as follows:—

5 lbs. blue vitriol (sulphate of copper).
5 lbs. quicklime.
50 gallons water.

Perhaps the simplest method of making it is as follows: Slack five pounds of the best quicklime in three gallons of water. Dissolve five pounds of blue vitriol, by frequently stirring, in three gallons of hot water in a wooden vessel. When both are cool, pour the slacked lime through a gunny sack strainer into two barrels containing twenty-two gallons of water each, and then pour in the blue vitriol solution. The result should be a sky-blue colored mixture that will settle to the bottom in a few hours. In use, it must be kept well stirred. If cold water is used, it will be found that the blue vitriol will dissolve most quickly if it is kept suspended at the surface of the water, as solutions of it are heavier than water. Of course, if it is stirred all the time, nothing would be gained by this treatment. When a large amount of Bordeaux mixture is to be used at the University Farm, we dissolve about twenty pounds of blue vitriol in twenty gallons of water, and in making the mixture, instead of weighing out the blue vitriol, we measure out one gallon of the solution.

The lime is used for the purpose of preventing any injurious action from the presence of soluble copper compounds. If the proportion used is five pounds of blue vitriol, five pounds quicklime and fifty gallons of water, as recommended above, there is no danger

from the presence of soluble copper compounds; but in practice we find it more convenient to slack a large amount of lime and then add it to the blue vitriol solution until the following simple test gives the proper reactions: Get from the druggist or chemist a few cents' worth of red litmus paper and cut it into strips about one-half inch wide. So long as there is free acid present, the paper will remain red or become a brighter shade of red, when wet with the mixture. When sufficient lime has been added, the litmus paper will turn deep blue if put into the Bordeaux mixture. If this simple test is used, there will be no injurious results from the Bordeaux mixture.

Bordeaux mixture should not stand more than a day or two before being used. It should be strained through gunny sacking, so as to remove all lumps that might clog the nozzle. It is best applied by means of a force pump having an especially prepared nozzle that will deliver it as a fine spray on the foliage. In a small way, for experimental purposes, it may be applied with a brush-broom. The nozzle which has given us the best success for this purpose is the "Bordeaux Nozzle," manufactured by the Deming Co., of Salem, Ohio.

INSECTICIDES FOR THE POTATO BEETLE.

The high price of Paris green as a poison for the potato beetle has stimulated inquiries for substitutes for it at a lower price. London purple is much cheaper than Paris green, but it has been found in practice that the results were not so uniformly successful with it as with Paris green, on account of the greater danger of burning the foliage. In our practice, for some time past, we have found that by using as much quicklime as London purple, in the water in which the poison was applied, that it was a safe and satisfactory poison to use. The past season it gave excellent results, but in order to have it work satisfactorily, we had to use it at the rate of one pound of London purple to about seventy-five gallons of water.

ARSENATE OF LEAD AS AN INSECTICIDE.

Arsenate of lead for use on potato vines to kill the beetles may be prepared as follows: Put eleven ounces of acetate of lead and four ounces of arsenate of soda into a hogshead containing 150 gallons of water. These substances dissolve quickly and form arsenate

of lead, which is a fine white precipitate that does not settle, but remains in suspension for a long time. If two quarts of molasses or glucose are added it aids in making the poison stick to the leaves. It adheres very tenaciously to the foliage, and the "gypsy-moth commission" of Massachusetts reports it as a most satisfactory insecticide. Boston parties offer the acetate of lead at 14 cents per pound and arsenic of soda at 8 cents per pound in twenty-five pound packages. This poison has given us good results the past season and is well worthy of trial.

INTERNAL BROWN ROT OF POTATOES.

During the past season the potato crop in a large part of Minnesota was affected with a new potato disease. In Ramsey and Hennepin counties probably one-half of the potatoes brought into market were affected with what has come to be known as rot, or brown rot. This disease affects the inside of the potato, while the outside appears perfectly healthy and normal. When the potato is cut open, the diseased condition shows very plainly as an aggregation of brown spots. These may accumulate directly through the

FIG. 2. Potato Infected with Internal Brown Rot.

center or near the outside, or, as in most cases, be distributed throughout the potato. It does not appear to decrease the amount of starch.

But little seems to be known about this disease. It seems to affect most varieties of potatoes, as shown in the following table, which gives the condition as regards this rot of thirty-one varieties which were grown at the University Farm in 1894:

TABLE LXVII.—Per Cent of Diseased Tubers Among Different Varieties of Potatoes.

NAME.	Per Cent of Disease.		NAME.	Per Cent of Disease.	
Acme	70	Badly discolored.	Ohio Jr.	50	Very bad.
American Wonder	10		Racquet Seedling	5	
Arizona	0		Reed's Eighty-six	5	
Beauty of Hebron	20	Badly discolored.	Red Ohio	0	
Crown Jewel	30	Slightly discolored.	Rural N. Yorker, No. 2	8	
Delaware	0		Snowflake	30	Very slight.
Early Ohio	80	Quite badly discolored.	Summit	8	
Early Oxford	10		Thorburn	20	
Early Rose	80		Vaughan	40	
Freeman	70	Very much discolored.	Vick's Champion	40	
Great Northern	10		Victor White	20	
Ideal	50		Western Red (Own)	10	Very litttle.
I. X. L.	60	Very bad.	Western Red (Bethel)	100	Very much discolored.
Late Rose (?)	55		White Prolific	5	
Lee's Favorite	70		World's Fair	20	Some very bad.
Maggie Murphy	60				

EXPERIMENTS WITH TOMATOES.

SAMUEL B. GREEN.

Six plants each of eighteen different varieties of tomatoes were set out May 29, 1894, in a plot of rich open clay land, sloping slightly to the south. The plants were rather tall; therefore, when planting, the lower part of the stems were bent over and covered. The rows were laid out six feet apart, and the plants were set as follows: Three plants of each variety were set five feet apart, then three more of the same variety, with three-foot intervals between the plants. The object of this was to allow room for the plants set five feet apart to spread on the ground in the usual form, while the plants set near together were to be trained on single stakes and pruned to a single stem. Those on stakes were closely watched, and the sideshoots were removed as fast as they appeared. This is the plan recommended very generally for the production of the earliest fruit. The results were as follows: Three varieties that were staked ripened before those plants of the same variety that were on the ground. Four varieties that were allowed to run naturally on the ground ripened before plants of the same kind that were staked and pruned. The results this season seem to indicate

that there is no profit in the practice of staking and trimming tomatoes in this section and under conditions similar to those that accompanied this experiment.

The following table gives the date of the first ripe fruit of all varieties. The third column gives the results of the total yield of the different varieties, but not the comparative yield, as it is well known that pruned plants produce less than those not trained; but the advantage claimed for the method is that more plants can be planted on the same amount of land, and that the increased earliness will much more than compensate for the lessened quantity:

TABLE LXVIII.—Tomatoes, Varieties and Date of Ripening of Staked and Not Staked Plants.

	Date of First Ripe Fruit.		Average Yield.
	Staked.	On Ground.	
Atlantic Prize	July 25.	July 25.	7
Buckeye State (Vaughan)	Aug. 25.	Aug. 11.	4
Chemin Market	July 24.	July 30.	3
Earliest of All (Vaughan)	July 20.	Aug. 11.	6
Early Acme	July 30.	July 19.	10
Dwarf Champion (Vaughan)	Aug. 3.	Aug. 3.	10
Dwarf Champion (Own)	Aug. 3.	Aug. 3.	10
Ignotum	July 30.	July 30.	7
Long Keeper	July 30.	July 30.	8
Meteor	Aug. 3.	July 30.	6
Matchless	Aug. 6.	July 30.	9
Northern Light	Aug. 3.	Aug. 11.	5
New Stone	Aug. 11.	Aug. 11.	5
Picture Rock	July 30.	July 30.	7
Royal Red	July 30.	July 30.	8-|-
Terra Cotta	Aug. 3.	Aug. 30.	6-|-
Trucker's Favorite	Aug. 3.	Aug. 3.	7-|-

It will be seen from the above table that the results as to earliness are very much in favor of the plants that were not staked but which were allowed to lie on the ground in the ordinary way. It will be noticed, also, that the varieties known as the Dwarf Champion and Early Acme produced the most fruit. These are excellent varieties in every way.

EXPERIMENT IN REGARD TO AMOUNT OF ROT FROM TOMATO VINES STAKED AND TOMATO VINES LEFT ON GROUNDS IN USUAL WAY.

The past season was a very favorable one for the tomato rot, and it was very abundant. There is, however, a great difference in the liability to rot of the various kinds of tomatoes, as will be seen from reading the notes on varieties. To determine the comparative

susceptibility to rot, of the fruit from trained and untrained vines, the fruit from each set of plants was carefully counted and a record kept of the diseased and sound fruit. The results will be found in Table LXIX. which follows:

TABLE LXIX.—Tomatoes,—Fruit Rotten and Sound, on Staked Vines and on Those Not Staked.

DATE OF PICKING.	Vines Trained to Stakes and Pruned.		Not Trained.	
	Rotten.	Sound.	Rotten.	Sound.
Aug. 27	40	40	70	100
Aug. 31	36	30	25	187
Sept. 3	20	60	40	225
Sept. 6	25	50	27	240
Sept. 11	21	90	25	225
Sept. 18	25	125	55	225
Total from Aug. 27 to Sept. 18	167	395	242	1,292

From the above table it will be seen that forty-three (43%) per cent of the tomatoes that grew on the staked plants rotted, while only nineteen (19%) per cent of the tomatoes rotted grown on the vines which were not trained but were allowed to spread out on the ground in the ordinary way.

DESCRIPTION OF VARIETIES OF TOMATOES.

Atlantic Prize.—Vines, medium in size; staked vines grew about five feet high. The fruit small; skin, red; flesh, pulpy and pink; form, rather flat, with some specimens very irregular.

Buckeye State.—Vines, very vigorous; staked vines grew seven feet high. Fruit, globular, large and smooth. The skin is of an even, pink color, except near the stem, which is a yellowish green. Flavor, very good. The plants grow too large for this climate, and unless trimmed back severely, very little fruit will ripen. Rotted some.

Chemin Market.—Vines, quite vigorous; fruit, apple shaped; color, red. Very little fruit ripened without rotting.

Dwarf Champion.—Vines, vigorous for a dwarf variety; leaves broad and heavy; fruit, globe shape; color, a good pink; medium in size; quality extra good; very few rotted.

Earliest of All.—Vines not very large; fruit, red, very irregular, very difficult to detach from the stem, ripens very early; not a good variety for market gardeners, but very desirable for gardens in

severe locations on account of its early ripening. About 20 per cent rotten.

Early Acme.—Vines, medium; fruit, medium in size and of a good pink color, globe-shaped. This variety rotted somewhat, but not over four per cent. A standard variety for marketing.

Ignotum.—Vines, medium in size; flesh, pink in color, with the skin red; shape round, somewhat flattened, often irregular. The season of fruiting is comparatively short; flavor rather poor; a few rotted.

Long Keeper.—Vines, very thrifty, but not quite as vigorous as Buckeye State; fruit, pink, medium in size, a little soft when ripe, and rotted badly.

Meteor.—Vines, of medium size; fruit, small to medium and quite seedy; flavor, fairly good; rotted quite badly.

Matchless.—Vines, quite large; fruit, red; skin thick; flat-shaped, with hollow at stem; rotted badly.

Northern Light.—Dwarf; fruit, small, pale red in color; skin, thin; flavor, poor; some rotted.

New Stone.—Vines, vigorous; fruit, large and quite smooth; color, a bright scarlet; does not ripen well near stem. This variety rotted more than any other, and it was very hard at any time during the season to get a healthy specimen.

Picture Rock.—Vines, medium to large; fruit large, somewhat flattened, rotted quite badly.

Royal Red.—Vines vigorous, skin of fruit red and flesh pink; quite seedy and soft; form, globular, slightly flattened; rotted badly.

Terra Cotta.—Vines, thrifty; fruit globe-shaped and pale red in color, soft and hollow; rotted quite badly.

Trucker's Favorite.—Vines, medium in size; fruit, pale red, resembling the Acme; rather pulpy, globe-shaped; ripens well to stem; many rotted.

SUMMARY.

(1) The results of this season seem to show that there is but little difference between the period of ripening of tomato plants that are pruned and trained to stakes and of those that are allowed to grow on the ground in a natural way, and consequently no profit from the operation of pruning. But these results are contrary to the experience of some of the most practical men, and should not be thought conclusive.

(2) The earliest variety was "Earliest of All," the seed of which was received from J. C. Vaughan, of Chicago. This variety is of special value for very short seasons. The Early Acme and Dwarf Champion, while about ten days later in ripening, yield much more and better fruit than the Earliest of All.

(3) Forty-three per cent of the fruit rotted that was produced by vines trained to stakes, while only nineteen per cent of the fruit rotted from vines allowed to grow naturally on the ground. This also is contrary to the usual experience of tomato growers, and should not be thought conclusive.

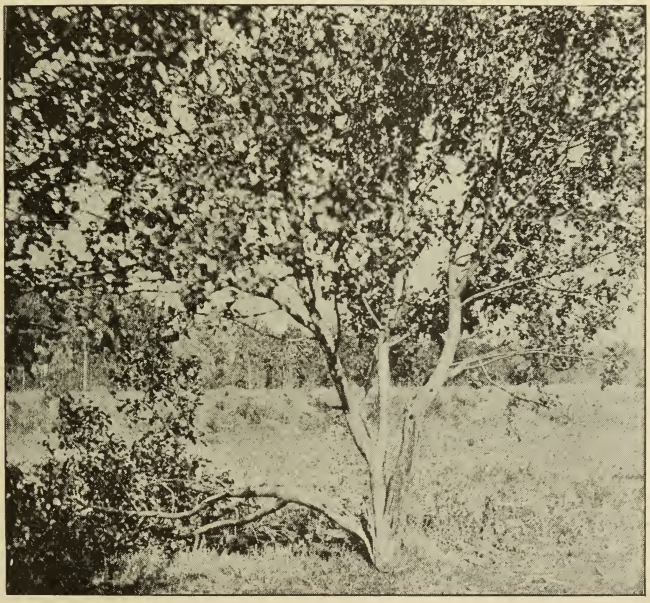

FIG. 3. Trunk of Apple Tree Showing Effect of Sun-Scald on Trunk.

APPLE-TREE SUN-SCALD.

SAMUEL B. GREEN.

It is probable that more apple trees that are well located and selected die from sun-scald in this state than from any other cause, and this loss is entirely preventable. By the term sun-scald

is meant the trouble that shows itself by the trees becoming rotten in the trunk on the south side, which finally so weakens it that it cannot support its top, and consequently breaks down, very likely when loaded with fruit. It is probable that this trouble is generally caused by a part of the bark on the south—or, more commonly, the southwest—side of the tree starting into growth before the rest of the tree, during some warm period in the latter part of winter or early in the spring. Such warm periods are generally followed by a severe freeze, in which case the newly-formed immature cells are ruptured, or the cell contents injured, which results in the bark on the affected side dying and falling off. Fig. 3 represents a Duchess of Oldenburgh apple-tree, which has been severely injured by sun-scald. One of the three parts of the trunk has so far rotted that

FIG. 4. Protecting Trunks of Trees from Sun-scald by Wrapping Them in Autumn with Cornstalks.

it has broken down to the ground, another part still stands, but is badly rotted on the southwest side for a distance of three feet and will probably break down in a short time; the other part of the trunk is still quite sound.

PREVENTION OF SUN-SCALD.

(1) Sun-scald may be prevented by anything that will shade the trunk and limbs; even a few branches furnish sufficient shade. If the top of the tree is kept inclined to the southwest until it is firmly established, it will shade the trunk sufficiently to prevent sun-scald.

There is a tendency in this section for all trees to incline to the northeast, due, largely, to the fact that the prevailing winds are from the southwest during the growing season and while the ground is soft. Trees that incline to the northeast receive the rays of the sun directly upon the trunk, and are most liable to sun-scald. In order to keep the tops of trees inclined to the southwest, they must be planted with a decided slant in that direction, though not so much so as to disfigure the trees. Even when this is done the trees will need annual attention to keep them in that position. One large and

FIG. 5. Protecting Trunk of Tree from Sun-scald by Shading with Board.

successful apple-grower in this state goes so far as to tie each tree to a small stake to hold it in position. If the trees are planted in Quincunx fashion, so that the rows run southwest and northeast, as well as north and south, they will largely shade one another when of bearing size.

(2) Protection by means of a screen of laths and wire woven together and wrapped around the trees is advocated, and has been extensively and successfully used. It is cheaply made and easily applied, but it does not fit the trunk well if the trees are crooked, and it should be supplemented by some material for shading the crotches, which are the weak spots of many kinds of apple trees. On straight trees it affords excellent protection to the trunks, and it is easily supplemented each autumn by stuffing the crotch with hay.

(3) Thin veneers of wood are manufactured which, when soaked with water, may be easily wrapped around the trunks and held in place by two wires. These have recently come into use, and are received with considerable favor by apple-growers. They are open to the same objection as the lath screen, but are easily supplemented in the same way, and are very desirable.

(4) Wire screen, such as is used for mosquito netting, has its advocates as protection against sun-scald. It has the merit of being more flexible than those mentioned before, and it easily conforms to the shape of the trunk. It is, however, necessary to supplement it with some material for protecting the crotches.

FIG. 6. Protecting Trunk of Tree from Sun-scald with a Wooden Box and the Crotches with Hay. To the Right, Trunk of Small Tree Protected by Wood Veneer.

(5) Flexible materials, such as burlap and building paper, is excellent for this purpose. They should, however, be taken off in summer and the burlap, when thus cared for, may be used for several years.

(6) An excellent method of protection is that given by wrapping the trunk of the tree with a hay rope or by tying cornstalks (Fig. 4) on the south half of the tree on the approach of winter. These

should extend up far enough to protect the crotches and lower branches as well as the trunk.

(7) The planting of a shrub, such as a barberry bush, an *Artemesia abrotans*, or similar hardy plant, on the south side of apple trees, has been recommended and to some extent practiced for the prevention of sun-scald.

(8) Protection by boards has been followed to a considerable extent. This is effected by standing up a six-inch board on the south side of the tree (Fig. 5) so as to keep the sun's rays off from the trunk. Sometimes two boards are nailed together, so as to partly inclose the trunk. This is an excellent method of protection. An objection to it is that unless the boards are very carefully placed the bark on the branches may be injured by them.

(9) Protection by boxing the trunks of the trees and filling the boxes with soil (Fig. 6) has come into use within a few years. This is probably the safest and most complete method known. It protects the trunk against sudden changes in temperature, as well as against sun-scald, and the adoption of this method of protection will undoubtedly make it practicable to grow the hardiest apple trees much farther north than it has been heretofore believed possible. This practice is especially adapted to the purposes of protection of the few trees so desirable in the farmer's garden and is worthy of very general use under such conditions. The expense for material is very little, and generally the necessary material for use in a small way can be had without any appreciable cost whatever. The question of removing the earth from the boxes in summer has been considerably discussed. At the University Farm the boxes filled with earth have been allowed to remain around a large number of the trees for three years, and no harm has resulted from the practice. Judging from this experience, I am of the opinion that no harm can result from the practice of allowing the boxes to remain on all the year round. However, if at any time the boxes were to be dispensed with, I should be very much afraid of removing them on the approach of winter, but if removed in the spring I do not think that their having been used would increase the susceptibility of the trees to injury from sun-scald. This method of protection, however, does not cover the crotches of the trees, and these should be protected as previously recommended.

The methods of protection suggested here as being such as should be left on all the year round, referred to in paragraphs 2, 3, 4, 5 and

9, protect from all injury from mice, and, to a large extent, fom all injury from rabbits, and on this account alone, in many sections, will be worth all they cost. While all varieties of apples are liable to sun-scald, some are much more subject to this injury than others. The varieties recommended by this Experiment Station and by the State Horticultural Society are most desirable for planting in this state. And the selection of other kinds, especially those that are generally grown in more favored locations, leads to disappointment and loss.

The extent of sun-scald is much greater in this section than is commonly thought. Besides the apple, the plum and cherry are occasionally thus injured, while sun injuries are very common on black walnut and basswood, and occasionally almost any of our deciduous trees are so affected. Newly transplanted basswoods are frequently injured by sun-scald when unprotected, and when used for street trees should always be shielded from the sun's rays, at least until well established and growing freely, after which such injuries are less frequent.

SUMMARY.

(1) Sun-scald is a frequent cause of loss of apple trees in the Northwest, and is entirely preventible at slight expense.

(2) Anything that will shade the trunks of the trees will protect them from sun-scald.

(3) Many methods that are admirably adapted to protect from sun injuries, also protect against injury from rabbits, mice and borers.

(4) It is recommended that planters of apple trees, on a small scale, at least, protect the trunks of their trees by boxing them up.

(5) All fruit trees should be inclined to the southwest when planted.

(6) Sun-scald affects most of our deciduous trees to some extent, and a few of them, under certain conditions, quite disastrously.

STRAWBERRIES.

SAMUEL B. GREEN.

The strawberry crop in 1894 has been generally a poor one on account of the late spring frosts when the plants were in blossom and the severe drouth which commenced to be injurious when the crop was about one-third grown. At the University Farm the crop was fairly good. I attribute our success to the fact that the beds are on a retentive soil well cultivated, and, also, to the fact that the mulch was kept over the plants until as late as practicable. Our beds were not in flower until after the damaging late frosts, and the space between the rows and around the plants being heavily mulched were protected from the sun and the rapid evaporation. Our beds which produced their second and third crop were much more productive than the new beds. I account for this from the fact that last season being very dry, the newly set plants did not perfect their fruit buds so well as the older and more vigorous plants of the old beds. But I would not wish to be understood as advocating the retention of old beds except where they are mowed over and renewed by plowing and manuring, according to the well known practice of this Station. By following the practice outlined above, we have not failed to secure at least a fair crop any year for four years at this Station. Of new varieties there is little to report, none of them having done better than the best of the older varieties. The most promising kinds for general planting are Warfield, Haverland and Crescent of the pistillate, and Beder Wood, Parker Earle and Enhance of the bi-sexual class. The best early berry here is the Warfield, the best late one the Parker Earle. The new kinds worthy of special mention are Swindle, Edgar Queen and Leader. These fruited in beds bearing their second crop. Other new kinds in the new bed did not have as good a chance as those in the old bed and should not be condemned on this account. The strawberry beds at the University Farm were sprayed with Bordeaux mixture in the spring, but they were very healthy, and no particular benefit seemed to follow this application. However, it is my opinion that it will, as a rule, pay well to spray at least once with this material in the spring, though there may be occasional years when there is no apparent benefit.

A tabular statement of the growth, period of ripening and productiveness of the following and other varieties was published in the "Minnesota Horticulturist" for August, 1894, and is consequently omitted here.

Atlantic (Bi-sexual)—Fruited in beds two and three years old. Quite productive; medium early; foliage and growth good.

Beder Wood (Bi-sexual).—Fruited in beds two, three and four years old, and very productive in each; blooms early and is full of pollen; fruit medium in size; season medium, holds on well; growth and foliage very good.

Boynton (Pistillate).—Early and holds on quite well; moderately productive. Nearly the same as Crescent.

Crescent (Pistillate).—As compared with the Warfield, which is taken as the standard, it ranked about third. Fruit not as large as Warfield, but it holds out better at latter end of season. This old variety is still one of the most reliable.

Edgar Queen (Pistillate).—Very vigorous both in foliage and growth and very productive; fruit large; a good variety and well worthy of trial by commercial growers.

Eureka (Pistillate).—Fruited in beds two and three years old. A very strong grower, foliage good; fruit of good size and color and firm; quite productive; season very long; worthy of trial.

Esther (Bi sexual).—Medium size, conical, red; quite productive.

Gillespie (Bi-sexual).—Foliage and growth poor, with little fruit.

Gov. Hoard (Bi-sexual).—Foliage and growth good; not very productive.

Great American (Pistillate).—Sets large quantities of fruit, but only a small part ripens; fruited in all beds and the results the same in each.

Greenville (Pistillate).—Foliage and growth vigorous; productive; season very long; fruit of good size.

Haverland (Pistillate).—An excellent variety. Season very long; yielded well in all beds; a close second to Warfield; fruit large.

Leader (Bi-sexual)—Very vigorous both in growth and foliage; very productive.

Lovett's Early (Bi-sexual).—A very handsome berry of good size; fairly productive.

Michel's Early (Bi-sexual).—An early flowering kind with an abundance of pollen; produces very little fruit. As a pollenizer it is very good, but otherwise almost useless.

Middlefield (Pistillate).—A fairly good grower; not very productive.

Ona (Pistillate).—Not very productive; fruit red, conical.

Parker Earle (Bi-sexual).—A large vigorous and thrifty grower; foliage good; season very late; fruit large; very productive. One of the best of the bi-sexual kinds.

Putnam (Pistillate).—Moderately productive; foliage and growth very good.

Saunders (Bi-sexual).—Fruit medium to large, compact; not very productive; foliage not very good.

Southard (Bi-sexual).—Medium in size, red, usually broad conical; fairly productive; foliage and growth good.

Standard (Bi sexual).—Of but little value here.

Stevens (Bi-sexual).—Season early, ripens well together, quite productive; foliage and growth good.

Swindle (Pistillate).—Fruit large, usually quite irregular, very firm; in large clusters; foliage and growth very good; very productive. A very promising variety.

Timbrell (Pistillate).—Plants large and vigorous, somewhat resembling the Bubach. I am disappointed in the amount of fruit it produced this year, which was very little, but as it fruited in the new bed and had been seriously dug into for plants I feel that it has hardly had a fair chance.

Tippecanoe (Bi-sexual).—A fairly good berry.

Warfield (Pistillate).—As in several previous years this variety stands at the head of the pistillate varieties. Yielded the most fruit of all the varieties; fruit medium in size, quite dark, very regular; fruited well in all beds.

West Lawn (Pistillate).—Of little value here.

Waupon (Bi-sexual).—Fairly productive.

Williams (Bi-sexual).—Fruit medium in size, broadly conical; clusters very large; somewhat seedy; moderately vigorous; does not ripen on end very well; fruited only in new bed.

RASPBERRIES.

SAMUEL B. GREEN.

The raspberry crop at the University Farm in 1894 was considerably shortened by the severe drouth, and yet the returns from the productive kinds compare favorably with the returns of other years. The raspberries here are grown in rows seven feet apart and are mulched for two feet on each side of the row. The three-foot space between the rows not mulched is kept loose by frequent stirring with a one-horse cultivator. On approach of cold weather the canes are bent to the ground and enough soil put on to hold them down, and

FIG. 7. Raspberries Laid Down for Winter.

then the whole row is covered with the mulch from between the rows. (Fig. 7.) The land on which they are grown is a loose clayey loam. In very severe locations, especially where the land is dry in autumn, this protection is not enough, but the canes should be covered their whole length with earth by plowing against them from both sides and then covering with mulch.

VARIETY TESTS OF RASPBERRIES.

TABLE LXX.—Variety Test.—"Tip-Rooting" Raspberries at University Farm in 1894.

VARIETIES.	Date of Blooming.	Date of First Picking.	Date of Last Picking.	Quality (scale 0 to 10).	Firmness (scale 0 to 10).	Vigor (scale 0 to 10).	Productiveness (scale 0 to 10).
	June.	July.	July.				
Ada	10	18	21	8	8	9	7
Brackett	8	10	22	7	9	7	8
Conrath's Early	6	1	20	8	9	9	9
Cromwell	6	4	16	8	8	9	9
Cook's Seedling	4	7	16	6	7	10	5
Gregg	10	9	20	8	10	10	8
Hopkins	4	7	....	8	9	8	8
Kansas	6	2	18	8	9	9	9
Lovett	8	6	20	7	9	8	4
Mystery	6	3	20	7	9	9	8
Nemeha	8	9	25	8	10	10	9
Ohio	6	6	25	9	10	9	8
Older	6	9	26	10		9	10
Palmer	7	4	18	7	8	8	6
Progress	8	6	26	8	8	8	8
*Smith's Giant	10	10	20	8	..	8	6
Smith's Prolific	6	2	23	8	8	8	7
Shaffer	12	9	24	8	9	10	10
Tyler	15	14	18	8	8	7	7
Wade	10	10	22	..	..	..	4
Wonder	10	11	22	..	..	..	3

*Suffered from drouth.

NOTES ON TIP-ROOTING RASPBERRIES.

Ada.—Bushes, medium in size and vigorous; spines, few as compared with others; flavor, a little tart.

Brackett's Seedling, No. 101.—Plants, thrifty; fruit, rather seedy.

Cook's Seedling.—Vines, very tall and thrifty; fruit, dark red, quite juicy, small, of inferior quality. This variety is reported by Mr. Dewain Cook, of Windom, Minn., as being exceedingly hardy and more productive than any of the other varieties he has grown.

Conrath's Early.—Vines, very thrifty and large; spines, strong; flavor, fair.

Cromwell.—A strong growing, productive variety.

Gregg.—Well and favorably known as one of the best late blackcaps.

Hansell.—A bright red, early berry; valued chiefly for its earliness.

Hopkins.—Vines of medium growth; fruit of fair size and good quality; quite productive.

Kansas.—Vines, very large, with many spines; very early and generally productive; fruit somewhat seedy.

Mystery.—Bushes, medium to large; fruit of fair size; not of good quality.

Nemeha.—A very reliable variety, closely resembling the Gregg, but think it rather more desirable and destined to supplant that kind.

Ohio.—One of the most productive of the early kinds. Of excellent quality and fine appearance.

Older.—Vines very vigorous and very productive; fruit of large size and good quality, and the fruiting season is a very long one. Rather too soft for shipment, but excellent for the near market and for home use. The most productive of the black-caps grown at the station the past season.

Palmer.—Very vigorous, very early and generally productive. One of our trial stations reports it as being the most productive of a number of popular kinds tried the past year.

Progress.—Very similar to Palmer in appearance, but a little later in ripening.

Shaffer.—An old, reliable and productive berry that is very desirable for canning. Its dull color makes it a poor berry to sell.

Smith's Giant.—Very late in season, and consequently suffered badly from the drouth. Plants made a good growth and set considerable fruit which failed to mature.

Smith's Prolific.—Vines, good size; fruit, medium too late in season, a little seedy and dry.

Wade.—Of fair quality, but not very productive.

Wonder.—Fruit, very poor; vines, not vigorous.

TABLE LXXI.—Raspberries.—Variety Tests of those which increase by suckering.

VARIETIES.	Date of Blooming. June.	Date of First Picking. July.	Date of Last Picking. July.	Quality (scale 0 to 10).	Firmness (scale 0 to 10).	Vigor (scale 0 to 10).	Productiveness (scale0 to 10).
Caroline	6	7	28	7	4	6	5
Champlain	12	9	24	9	..	8	7
Clark	10	7	28	9	8	9	8
Cuthbert	10	9	27	9	9	9	8
Gladstone	12	7	25	4	4	10	3
Golden Queen	10	9	26	9	9	9	8
Hansell	10	9	28	9	9	7	9
Kenyon's Seedling	2	12	24	7	9	9	9
Marlboro	8	6	28	6	10	7	9
*Reliance	10	10	..	5	9	5	..
Royal Church	5	15	24	7	6	10	..
*Superlative	10	9	20	..	5	..	..
Thompson's Early	10	9	24	9	8	9	8

*Very badly affected with "Leaf Curl"

NOTES ON THE VARIETIES OF RASPBERRIES WHICH ARE PROPAGATED BY SUCKERS.

Caroline.—Golden yellow color. Vines, low and bushy. It sets large quantities of fruit, which is rather acid.

Champlain.—Nearly white in color and rather sweet; foliage, very heavy and dark. Vines very bushy and heavy. Not sufficiently productive here to be of any value.

Clark.—Bushes, medium size; flavor of fruit very good. A very good variety for general planting.

Cuthbert.—An old, popular variety that does well where it is healthy. In some sections it is badly diseased.

Golden Queen.—Bushes, medium in size, productive; fruit large, golden yellow in color and of good quality.

Kenyon's Seedling.—Bushes, medium in size, quite vigorous; fruit, quite large and firm, but crumbles a little; color, deep dark red; quite productive on bushes that were large enough to bear well. Berries cling to the stems very closely and must be well ripened before they will separate; flavor, fair.

Logan.—Received from California in spring of 1894. Growth, very vigorous. In appearance it closely resembles the dewberry, and is propagated the same way. The foliage is of a dark purplish color and very healthy. Have not fruited it.

Marlboro.—Perhaps the most valuable of all red raspberries for market, although of inferior quality. Careful attention, however, should be given to having all the sets of the plant very healthy, as it is quite liable to the disease known as leaf curl.

Reliance.—Our plants of this kind have become badly diseased with the leaf curl.

Royal Church.—Vines recently planted are very vigorous and healthy. But very little fruit produced, and that seemed to have a tendency to crumble.

Superlative.—Judging from its appearance here, I think it one of the most worthless varieties ever sent out.

Thompson's Early.—Vines, healthy and vigorous; fruit, of good size and color and very sweet; quite productive. It seems to be a promising early variety.

Turner.—A reliable, well known variety, especially desirable for home use, and recommended as best for severe locations.

CANE RUST OF RASPBERRIES (ANTHRACNOSE).

On account of the adverse season of 1894, the cane rust (anthracnose) and the disease commonly known as "leaf curl" were unusually destructive, and in some sections of the state seriously lessened or destroyed the crop. Some varieties are much more subject to these diseases than others, and few, if any, kinds are entirely exempt from them. Cane rust is probably always present in a small way in raspberry plantations (see Fig. 8), but in average seasons vigorous

FIG. 8. Raspberry Cane Affected with Cane Rust.

plants are able to resist the disease and mature a crop of fruit, while in very dry seasons the plants cannot perfect the fruit, the wood for the next year and the disease, and as a consequence the fruit is the part that is especially liable to suffer. A peculiar trait of this disease is that it does not seem to affect the vigor of growth of the young canes, but injures the crop just when it is ripening. Experiments are in progress at the station in combating these diseases, and we seem to have been quite successful in preventing the cane rust (anthracnose).

Treatment for Cane Rust of Raspberries.— Judging from the result of experiments in the prevention of cane rust at the University Farm and elsewhere, it would seem that the most rational treatment for it is as follows:

In the spring, before the canes start, spray them with a solution of sulphate of copper (blue vitriol) made by dissolving one pound of it in fifteen gallons of water. Later, spray the new canes with Bordeaux mixture, probably about three times, at intervals of about two weeks, commencing as soon as the new canes are one foot high. Care should be taken not to get the Bordeaux mixture on the leaves of the fruit-bearing canes, as they are quite liable to be burned by it.

May 6, 1895.

UNIVERSITY OF MINNESOTA.

AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 40.

AGRICULTURAL DIVISION.

DECEMBER, 1894.

GRAIN AND FORAGE CROPS.

CORN, variety tests, Silage of Flint, Sweet, Southern Ensilage and Dent, compared as food for dairy cows, improved varieties, corn cultivation and cultivator trials, listing, hilling, pruning the roots of corn; WHEAT, variety tests, varieties chosen for propagation, varieties originated by selection, crossing and selecting; BARLEY, variety tests; FLAX, variety tests; FIELD PEAS, variety tests; MILLET, variety tests; SUCCOTASH of oats and wheat grown together; OATS, methods of seeding, rolling to prevent lodging; HAY, production by seeding annual fodder crops; SEEDING IMPLEMENT TESTS; WHEAT, OATS, BARLEY AND FLAX, time and depth of seeding; FIELD MANAGEMENT AND ROTATION OF CROPS, SMUT IN WHEAT, blue stone sprinkling and dipping methods and hot water treatment.

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.

ST. PAUL:
THE PIONEER PRESS CO.,
1895.

UNIVERSITY OF MINNESOTA.

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☞ The bulletins of this station are mailed free to all residents of the state who make application for them.

FORAGE AND GRAIN CROPS.

WILLET M. HAYS.

Experience with field crops and the management of lands in 1894 has illustrated the need of repeating experiments several times in order to obtain results of much value. The excessively dry summer season made valueless at least fifty per cent of the trials begun and lessened the value of most of the others at the University Farm. Nearly every crop grown on the 200 acres of tillable land on the University Farm was in some way experimented with, while on over one-third of the cultivated area the land was divided into plots. The labor of attending to these several hundred plots was nearly all done by young men who attended the School and College of Agriculture during winter and were employed at farm wages during summer. Never before had I observed such a faithful, trustworthy and efficient lot of farm hands at work together. The School of Agriculture dignifies labor, and these young men were examples daily of the fact that our school is giving to the state a class of trained enthusiasts in farming. Mr. Warren W. Pendergast and Mr. Wm. G. Smith, two graduates of the School of Agriculture and now juniors in the college course in agriculture, did especially efficient and intelligent service in the management of experiments and in the careful work of breeding farm crops. Each was given a month's experience as foreman of the farm, and each proved able to handle men and care for business. Mr. Andrew Boss, the farm foreman, had immediate charge of most of the details of the experiments of the division, and greatly assisted in planning and in compiling and arranging the tabular matter of the following reports. His accuracy and efficiency are worthy of most hearty commendation. In the study of rotation of crops, Prof. Harry Snyder has joined me, and the experiments somewhat as outlined in the last part of this report will be carried out by the

divisions of agriculture and chemistry. In the spring of 1894 the board of managers of the State Farmers' Institutes rented of Supt. O. C. Gregg his 360 acre farm in Lyon county and turned it over free to the experiment station. Under the terms of the lease Superintendent Gregg furnished teams, machinery and all other equipments needed. Mr. T. A. Hoverstad, a graduate of the school and of the college courses, was placed in charge of the experiments, and Mr. Gregg also was able to spend a large part of the summer at the farm. Here a few hundred plots were devoted to experiments, and in spite of late seeding, caused partly by the strike on the Great Northern Railway, a fairly large per cent of the experiments were successful. The arrangements for renting the farm were not perfected until rather late in the season. Many of the experiments were duplicates of those under way at the University Farm. The results have been incorporated in the following report with those of the trials at St. Anthony Park, and are designated as from "Coteau Farm," the name by which Mr. Gregg's homestead is known. While the farm was in good condition, the first year's work on it was, as a matter of necessity, in part, spent in planning and arranging for the future. The land is fertile and proved quite uniform and well adapted to plot work. Here we hope to make prominent the experiments in conserving moisture in our soil in drought, the production of grasses and annual forage crops, and to demonstrate practical and new facts regarding field and farm management. Mr. Hoverstad has shown his fitness for managing experiment work, and our thanks are due Superintendent Gregg for his enthusiastic aid and valuable co-operation. This work was so managed that a net cost to the station of less than $500 was incurred during the first year.

Good progress has been made in the testing of varieties of wheats, corn, oats, and other staple crops, and now that we have a number of tests of each variety and have determined what are best, the proper thing seems to be to propagate these in quantities to distribute to the farmers. Choice seed of a few kinds of dent corn is already on hand, and in a very few years we can have fairly large quantities of the best spring wheats which we have been able to find in the world. In like manner, choice varieties of other crops can soon be produced in quantities large enough to distribute to many farmers. Not content with the best kinds of corn, wheat, oats, barley, field peas, timothy, etc., which the world affords, we have

well under way numerous new varieties produced by selection and by a combination of crossing and selection. The best of these newly originated sorts will be tried in comparison with kinds collected from every available source which have proved best, and if found superior the new kinds will be grown in quantity for distribution to farmers of the state. The secretary of agriculture has recommended to congress in his last annual report that the government furnish each state with its proportion of the money now expended for seeds and allow the experiment stations the franking privilege, that they might thus be able to send out improved seeds grown especially for the conditions prevailing in each state. With the start we already have at obtaining and breeding superior varieties we could at once make excellent use of the share of the money that would come to this state. The distribution of seeds on the plan here outlined has done much in Canadian provinces and territories to increase the average yield of crops for the entire Dominion.

VARIETIES OF CORN FOR MINNESOTA.

A study of the varieties of corn adapted to the wants and conditions of Minnesota farmers, begun in 1888, was seriously interfered with in the fall of 1890 by the destruction by fire of many of the notes and a stock of carefully selected seed of varieties gathered in previous years. A partial collection of seed was again made in 1891, when about twenty-five varieties were tried. The best of these were used and more good varieties have since been collected. Table LXXII. shows the yield of those found best through a series of years and others more recently procured to test with them. The farmers of the southern one-third of the state want for field culture, for grain and fodder, medium sized dent varieties of corn, which will ripen by the 15th to 20th of September and will yield a large amount of grain. The stover can be produced so cheaply with the grain that especial attention to the yield of stover in these varieties hardly needs consideration. The larger flint varieties and the few large sweet varieties are useful in special cases in the southern one-third of the state, as on wet, cold soils, and in situations not so well suited to the growth of corn as are most parts of that section. The large sweet varieties seem especially well suited to grow for silage and for fodder where a large yield only of coarse forage is desired. Where corn is grown for ears, however, the dent varieties are the

best we have found. A crop of dent corn is generally made up of nearly one-half ears, while a crop of the much branching sweet or flint corn is only about one-third ears and two-thirds fodder. Dent varieties are much easier husked than flint corn, though much depends upon the variety in each class. For the central third of the state some of the very earliest dent varieties of corn are suitable for growing on good arable lands in rotation with small cereals. But the larger and medium-sized flint varieties will, as a rule, be quite as profitable in this section. They ripen earlier and make a large amount of fodder per acre. Medium-sized sweet varieties, which ripen fairly early, can also be developed into most useful fodder crops for the center of the state.

For the northern third of Minnesota small, early maturing flint and sweet varieties of corn give the best results for fodder, and even for grain. For growing thickly for fodder, varieties much larger than those grown for grain and fodder combined can be used. Small, early varieties of dent corn may be found which are good yielders of grain and of fodder.

All our farmers should pay more attention to corn, and learn how it will make cheap fodder and grain, even in the most northern sections of the state; and, what is nearly as important, that it leaves the land in better condition for wheat and other small grains than does even the summer fallow. Seed of varieties best suited to northern sections for fodder can best be grown in central or southern Minnesota. Some arrangement should be perfected by which reliable seedsmen, or other reliable parties, will know what kind of seed is wanted in each section of the state, so that farmers in each section will be sure of getting the seed corn best adapted to their needs. In the northern sections they can raise their own seed of the small, early varieties during years when early frosts do not occur.

It has been our general experience that flint and sweet varieties produce more fodder than dent varieties, though they generally yield less grain. Last year the yields were much lessened by the drought. Some years since experiments were conducted with dent, sweet, flint and southern corn for silage, but the report has awaited further experiments on varieties before publication and is given below.

In Table LXXII. are shown the yields of varieties of corn we now have on hand. Nos. 5, 6, 7 and 13 are proving superior varieties, having yielded well through a series of years. Of some of these we are growing large quantities of seed, and hope to be able to sell or to distribute free in the near future.

TABLE LXXII.—Corn, Variety Tests.

University No.	VARIETY.	SOURCE.	Class.	Height of stalk.	cent. stools.	Distance.	Proportion of blades.	Ear from ground.	Length of ear.	Per cent. marketable ears.	Days maturing.	Lbs. field dried corn to 1 bu. dry shelled corn.	Yield per acre, 1894.		Yield 1893.	Yield 1892.
													Stover.	Shelled corn		
1	Cosgrove's Yellow Dent	J. Cosgrove, Le Sueur	.....	6	5	.....	80	30	10	.....	105	76.7	3,333	40.3	.....	.....
2	Gold Corn, Yellow Dent	A. O. Smith, Clearwater	.....	5½	10	.....	78	27	6	.....	103	69.5	2,576	38.1	55	.....
3	Minnesota King	N. B. & G. Co	.....	5	15	.....	82	24	9	.....	105	76.8	2,576	33.6	50	.....
4	Queen of the North	N. B. & G. Co	.....	6	12	.....	82	24	6	.....	103	69.5	3,394	42.8	56	.....
5	Hoag's Yellow Dent	Hoag, Rochester	.....	5½	12	.....	84	28	2	.....	103	70.3	3,273	41.9	.....	46.2
6	Lamb's Yellow Dent	W. H. Lamb, Waseca	.....	5½	10	.....	84	26	8	.....	105	73.6	2,576	44.3	67	54.9
7	Allyn's Yellow Dent	J. Allyn, Red Wing	.....	6	12	.....	80	30	8	.....	107	70.3	3,030	42.3	54	41.6
8	Dakota Yellow Dent	N. B. & G. Co	.....	6¼	10	.....	80	28	8½	.....	109	72.3	3,697	34.6	58	.....
9	New York Yellow Dent	L. P. Smith, New York	.....	6	5	.....	82	30	8	.....	107	76.8	3,575	37.5	55	.....
10	Earliest Canadian Yellow Dent	Salzer, La Crosse	.....	6	10	.....	80	28	8	.....	107	78.3	3,787	44.6	67	.....
11	Southern Yellow Dent	Nebraska	.....	8	5	.....	80	42	11	.....	.....	112.0	8,848	24.1	.....	.....
12	Dakota Queen	N. B. & G. Co	.....	6	10	.....	82	30	7	.....	109	74.6	3,847	44.5	62	.....
13	St. Paul Yellow Dent	De Cou & Co , St. Paul	.....	6¼	10	.....	84	30	8	.....	109	74.6	3,150	46.9	62	47.8
14	Sutherlin's No. 1	Sutherlin Bros, White Sulphur Springs, Mont	.....	6	5	.....	75	24	7	.....	109	72.0	4,848	39.7	.....	.....
15	Calico Yellow Dent	Iowa	.....	6½	15	.....	84	32	11	.....	107	73.6	5,355	57.4	.....	.....
16	Sutherlin's No. 2	Sutherlin Bros	.....	5½	15	.....	75	24	8	.....	105	74.6	1,969	34.3	.....	.....
17	Boyd's Yellow Dent	A. Boyd, Verndale	.....	5	15	.....	76	20	8	.....	103	73.6	2,516	39.1	.....	.....
18	Beaver's Yellow Dent	Cline Beaver	.....	7	12	.....	80	36	12	.....	110	79.0	8,182	58.9	.....	.....
19	Sutherlin's No. 3	Sutherlin Bros	.....	6	15	.....	78	24	8	.....	105	70.3	3,757	35.3	.....	.....
20	Brown's Pride	Iowa	.....	6½	5	.....	80	34	10	.....	105	70.3	4,242	47.0	.....	.....
21	Conqueror	N. B. & G. Co	.....	7½	5	.....	75	48	10	.....	117	98.3	8,033	35.6	.....	.....
22	Southern White Dent	Nebraska	.....	9	3	.....	75	60	10	.....	117	126.0	13,576	31.6	.....	.....
23	Berg's White Dent	Jacob Berg	.....	5½	5	.....	75	20	7	.....	103	72.9	2,879	45.9	.....	.....
24	Cosgrove's Yellow Flint	J. Cosgrove, Le Sueur	.....	6	15	.....	80	26	8	.....	103	79.0	5,303	56.3	.....	.....
25	Norrish Yellow Flint	A. F. Norrish, North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
26	Minnesota Yellow Flint	Twombler, Wyoming, Minn	.....	5½	20	.....	82	24	.....	.....	103	80.6	7,121	45.2	44	.....
27	Minnesota Yellow Flint	Twombler, Wyoming, Minn	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
28	Minnesota Flint	Twombler, Wyoming, Minn	.....	5	28	.....	84	24	13	.....	103	80.6	4,242	31.2	.....	.....
29	Mercer's Yellow Flint	De Cou & Co., St. Paul	.....	5	20	.....	80	20	9	.....	103	79.0	3,454	39.1	42	.....
30	New York Yellow Flint	L. P. Smith, New York	.....	6	25	.....	82	24	11	.....	103	76.7	5,757	43.3	54	.....
31	Long Yellow Flint	James Thorburn, New York	.....	6	25	.....	82	28	12	.....	112	93.7	6,212	32.1	.....	.....
32	Squaw Corn	Salzer, La Crosse	.....	5	15	.....	80	24	12	.....	99	76.7	3,637	38.0	42	.....
33	New York White Flint	L. P. Smith, New York	.....	6	15	.....	80	28	12	.....	103	76.7	5,151	40.0	.....	.....
34	North Dakota White Flint	Salzer, La Crosse	.....	5	20	.....	80	24	10	.....	103	83.1	5,151	42.3	.....	.....
35	Early Minnesota Sweet Corn	N. B. & G. Co	.....	4	25	.....	75	18	7	.....	103	81.4	3,333	27.6	.....	.....
36	Stowell's Evergreen Sweet	N. B. & G. Co	.....	6	20	.....	82	26	7	.....	122	98.3	6,666	48.8	.....	.....
37	Cosgrove's Sweet	J. Cosgrove, Le Sueur	.....	6¼	20	.....	80	26	.....	.....	122	97.1	4,848	38.4	.....	.....
38	Long Sweet	N. B. & G. Co	.....	3½	25	.....	75	18	.....	.....	103	89.6	3,333	13.4	.....	.....

SILAGE OF FLINT, SWEET, SOUTHERN AND DENT CORN COMPARED.

In 1888 this station began experiments to compare the various classes and varieties of corn for silage adapted to Minnesota. In a report of the work for that year the belief was expressed that "it is best to grow for silage in each latitude those kinds of dent corn which are slightly too large to ripen but will become mature enough for silage, or will reach the glazing stage." Far northward the flint varieties which will reach this stage may be used for silage, thus pushing the corn belt far beyond its present line. Further experiments made during subsequent years go to substantiate this statement. Some of the large sweet varieties would also seem worthy of use for silage in the southern half of the state, and some small earlier ripening sweet sorts would doubtless serve this purpose to the northward. Rather larger, later maturing varieties of dent corn than any mentioned in Table LXXII. may be used for silage, though several varieties of dent and flint corn there described yield well for silage.

In 1889 dent and flint corn were grown in check-row hills in the ordinary field way, while southern ensilage corn was grown in drills forty inches apart and stalks averaging eight inches apart in the rows. The varieties of dent and flint corn used were those known to ripen in this neighborhood a little before frosts. The dent and flint each yielded nine and three-fourths tons of well eared silage per acre, while the southern ensilage corn yielded twenty-one and a half tons of green fodder per acre. The southern ensilage corn contained 18.57 per cent of water-free substance, while the fresh dent silage contained 23.17 per cent of water-free substance. The analysis of the flint silage, together with material for other analyses, and other notes, were destroyed by the burning of the station office. As the flint silage had within a fraction of one per cent of the same dry matter as the dent silage the same figure is used. Notes of variety tests for yield per acre in 1889 and 1890, including more than forty varieties, were also burned. The three kinds of silage were fed to cows to determine their relative value in the production of butter and milk. To Group I., composed of six Holstein-Friesian cows, the southern ensilage corn of 1889 was fed in 1890 in comparison with silage of dent corn. To Group II., composed of one Shorthorn, one Jersey and one grade Guernsey cow, silage of flint corn was fed to compare with silage of dent corn. These Holstein-Friesian cows, in Group I., were kindly loaned the station by S. Leslie, Waseca, Minn., who loaned Chuckle No. 4; D. E. Branham, Litch-

field, who loaned Speerstra and Sig Hedrikje 2d, Nos. 1 and 2; I. C. Wade, Jamestown, N. D., who loaned Vinnie 3d and Nadine Abbekirk, Nos. 3 and 5, and N. J. Leavitt, Waseca, Minn., who loaned Graceful, marked "G" in Table A; H. F. Brown, Minneapolis, Minn., furnished the Shorthorn cow, Bell Brown No. 7, in Group II.; W. D. Richardson, Garden City, Minn., loaned a grade Guernsey No. 14, and D. W. Casseday of Hutchinson loaned Hazel, a Jersey grade No. 15. The thanks of the station are due all these men.

The silage was fed with a given proportion of grain and other fodder. The silage of dent corn was used as a basis with which to compare both of the other kinds of corn. Each of the two groups of cows was fed during three periods of twenty-one days, with preliminary periods of seven or more days. The dent corn was fed during the first and third periods to each group. During the second period Group I. had southern ensilage corn silage and Group II. had flint corn silage. By this method the average results of the first and third periods were compared with the results of the second period. Since the cows were gradually falling off in milk and butter yield, as they got farther along in the period of lactation, this plan gave a fair comparison of the two kinds of silage fed to either group of cows. A year later silage of dent, sweet and southern ensilage corn were compared in the same way as is reported herewith.

SOUTHERN ENSILAGE VS. DENT CORN FOR SILAGE.

Group I. was given, during the first and third periods, all the cows would eat in three feeds per day of a ration made up as follows:

Silage of dent corn	40 pounds
Bran	8 pounds
Oil cake	2 pounds
Timothy hay	3 pounds

Previous experience and reason taught that more of the southern corn silage should be given during the second period than was put in the ration above of the dent corn, which contained considerable grain. As the percentages of dry matter, 23.17 and 18.57, were practically as five is to four, fifty pounds of the silage of southern corn were put with the eight pounds bran, two pounds oil cake and three pounds timothy in the second period in place of the forty pounds of dent silage fed in the first and third periods. The feeding was very carefully done by Charles Kerr, herdsman, and very little irregularity occurred. At the end of the first periods and during the pre-

TABLE LXXIII.—Group I.—Six Holstein-Friesian Cows.

Fed First and Third Periods a Ration of Forty Pounds Dent Corn Silage, Eight Pounds Bran, Three Pounds Timothy Hay (Chaffed) and Two Pounds Oil Meal. Fed During the Second Period Fifty Pounds Silage of Southern Ensilage Corn in Place of Forty Pounds Dent Corn Silage Fed in Periods 1 and 3.

FIRST PERIOD.—JANUARY 13TH TO FEBRUARY 2D.

Number.	Feed Given.	Milk Given.	Total Butter Fats.
No. 1	1,498	708.25	29.18
No. 2	1,330	824.25	28.93
No. 3	1,392	624.75	24.30
No. 4	1,329	652.00	26.08
No. 5	1,384	527.00	21.61
No. G	1,684	946.00	33.01
Totals	8,617	4,282.25	163.11

SECOND PERIOD.—FEBRUARY 18TH TO MARCH 10TH.

No. 1	1,928	653.00	25.47
No. 2	1,746	772.25	26.87
No. 3	1,811	555.00	21.64
No. 4	1,687	505.5	18.70
No. 5	1,251	418.25	16.94
No. G	1,987	749.5	27.73
Totals	10,410	3,653.5	137.35

THIRD PERIOD.—MARCH 18TH TO APRIL 7TH.

No. 1	1,554	640.75	26.27
No. 2	1,091	648.75	23.48
No. 3	1,491	587.5	23.03
No. 4	1,364	489.00	19.90
No. 5	1,312	464.25	18.37
No. G	1,607	724.75	27.83
Totals	8,419	3,555.00	138.88

Summary.

	Feed Given.	Milk Given.	Total Butter Fats.	Lbs. Feed to 1 Lb. Milk.	Lbs. Feed to 1 Lb. Butter.	Lbs. Milk to 1 Lb. Butter.
Periods 1 and 3 (dent corn)	17,036	7,837.25	302.0	2.17	56.4	25.95
Period 2 (southern ensilage corn)	10,410	3,653.5	137.4	.....	.....	.....

Summary.

Silage in Period 2 reduced to same dryness as in Periods 1 and 3.

Periods 1 and 3 (dent corn)	17,036	7,837.25	302.0	2.17	56.4	25.95
Period 2 (southern ensilage corn)	*8,758	3,653.5	137.4	2.4	63.7	26.6

*The water in the daily ration in Period 2, when southern corn silage was used, was more than when dent corn silage was fed in the first and third periods, and is here simply eliminated to get a comparison of dry matter of silage, the grains and hay, making up the rest of the ration, remaining the same in either case.

TABLE LXXIV.—Group III.—Six Native Cows.

Fed First and Third Periods Dent Corn and Second Period Southern Corn Silage with Grain and Hay same as Group I.

FIRST PERIOD.—DECEMBER 27TH TO JANUARY 7TH, INCLUSIVE.

Number.	Feed Given.	Milk Given.	Total Butter Fats.
No. 4	780	239.25	9.69
No. 5	612	214.25	9.86
No 6	720	202.00	7.53
No. 7	792	256.00	11.26
No. 8	792	221.75	9.98
No. 9	693	205.25	9.95
Totals	4,389	1,338.5	58.27

SECOND PERIOD.—JANUARY 14TH TO 25TH, INCLUSIVE.

No. 4	834	239.00	8.60
No. 5	713	214.75	8.22
No. 6	692	161.25	6.84
No. 7	900	233.00	9.44
No. 8	900	197.5	7.80
No. 9	784	195.5	8.60
Totals	4,823	1,241	49.5

THIRD PERIOD.—JANUARY 30TH TO FEBRUARY 10TH, INCLUSIVE.

No. 4	766	230.00	8.74
No. 5	612	205.00	8.28
No. 6	640	179.00	7.52
No. 7	827	233.25	9.45
No. 8	827	196.00	8.23
No. 9	720	189.5	7.71
Totals	4,392	1,232.75	49.93

Summary.

	Feed Given.	Milk Given.	Total Butter Fats.	Lbs. Feed to 1 Lb. Milk.	Lbs. Feed to 1 Lb. Butter.	Lbs. Milk to 1 Lb. Butter.
Dent corn silage (Periods 1 and 3)	8,781	2,571	108.2	3.4	81.1	23.8
Southern ensilage corn silage (Period 2)	*4,057	1,241	49.5	3.3	82.0	25.1

*Silage in Period 2 reduced to same dryness as in Period 1.

liminary feeding for the second period one or two cows were quite seriously "off their feed," and in one or two cases during the course of the second period there was slight indisposition, but on the whole these Holstein-Friesian cows sustained the hardy good feeding reputation for which the breed is noted.

The comparison of dent versus southern corn silage was again made with corn grown in 1890. Six "native" cows, picked up in

Swift county by Col. W. M. Liggett to supply milk for the school, were fed during three periods of twelve days each, and in a manner similar to the feeding of the six Holsteins during the previous winter. The cows stood this ration well, and gave a fair test of the two feeds as summarized below. Here again, as the relation of the dry matter in the two was about as five is to four, fifty pounds of southern corn silage in the second period replaced forty pounds of dent silage in periods one and three.

Above is a summarized statement of food eaten, milk given and butter yield as calculated from chemical analysis of the milk, and also other summaries of the results.

FLINT VS. DENT CORN SILAGE.

To compare silage of dent and flint corn, Group II., composed of three cows, was given, during the first and third periods of twenty-one days each, forty pounds dent silage grown in 1889, eight pounds bran, two pounds oil cake and three pounds timothy hay. As the flint corn silage had practically the same percentage of dry matter as the silage of dent corn forty pounds of flint corn silage were given in the second period in place of the forty pounds of dent corn silage. The dry matter in both kinds of silage was practically twenty per cent. The following tabular statement shows the results.

When tried in various ways the cattle showed a greater liking for the other kinds of silage than for silage of flint corn, though this corn was cut when no riper than the dent corn.

SWEET VS. DENT CORN SILAGE.

During the early part of 1891 two cows were fed silage of sweet corn in comparison with silage of dent corn grown in 1890. The dent corn was similar to that used in the comparison with southern ensilage corn in two trials here reported and the one trial of dent versus flint corn also reported here. As there was little difference (less than one per cent) in the percentage of moisture in these two kinds of silage, forty pounds of sweet corn in the second period took the place of the forty pounds of dent corn silage fed in the first and last periods, and eight pounds bran, three pounds timothy and two pounds ground oil cake was the grain ration mixed with the silage in this, as in the other cases above mentioned. These were native cows, also purchased in Swift county.

TABLE LXXV.—Group II.—Flint vs. Dent Corn Silage.

FIRST PERIOD.—JANUARY 17TH TO FEBRUARY 6TH, INCLUSIVE.

Number.	Feed Given.	Milk Given.	Total Butter Fats.
No. 7	1,218	582.75	24.48
No. 14	913	469.25	23.79
No. 15	787	303.25	17.61
Totals	2,918	1,355.25	65.88

SECOND PERIOD.—FEBRUARY 18TH TO MARCH 10TH, INCLUSIVE.

No. 7	1,448	526.00	22.88
No. 14	945	291.75	19.59
No. 15	943	292.00	17.08
Totals	3,336	1,209.75	59.55

THIRD PERIOD.—MARCH 18TH TO APRIL 7TH, INCLUSIVE.

No. 7	1,335	513.00	21.34
No. 14	882	340.25	19.12
No. 15	825	261.75	15.36
Totals	3,042	1,115.00	55.82

Summary.

	Feed Given.	Milk Given.	Total Butter Fats.	Lbs. Feed to 1 Lb. Milk.	Lbs. Feed to 1 Lb. Butter.	Lbs. Milk to 1 Lb. Butter.
Dent corn silage (Periods 1 and 3)	5,960	2,470.25	121.7	2.41	49.00	20.3
Flint corn silage (Period 2)	3,336	1,209.75	59.55	2.75	56.00	20.3

SUMMARY.

1. A hundred pounds of dry matter in either dent, sweet or southern ensilage corn silage proved nearly of equal value for producing milk and butter in these trials, though the advantage in all cases was slightly in favor of the silage of dent corn. This corn bore a fair crop of ears.

2. Flint corn silage did not prove as good in this one trial for producing milk and butter as dent corn silage.

3. Cattle did not seem to relish silage of flint corn as well as silage of the other three classes of corn.

4. Where a large amount of silage is wanted from a small area of land to feed with cheap mill feeds, these results would indicate that the most feed can be procured by using, in any given locality, corn so large that it will barely pass the roasting ear stage, before frosts. Here large field corn from the latitude of Missouri would probably make the most feed per acre.

TABLE LXXVI.—Group IV.—Sweet vs. Dent Corn Silage.

FIRST PERIOD.—JANUARY 7TH TO 18TH, INCLUSIVE.

Number.	Feed Given.	Milk Given.	Total Butter Fats.
No. 1	701	180.75	7.23
No. 2	732	337.5	15.18
Totals	1,433	518.25	22.41

SECOND PERIOD.—JANUARY 31ST TO FEBRUARY 11TH.

No. 1	716	190.25	8.31
No. 2	827	321.25	12.11
Totals	1,543	511.5	20.42

THIRD PERIOD.—FEBRUARY 15TH TO 26TH, INCLUSIVE.

No. 1	699	176.25	7.70
No. 2	874	307.75	12.61
Totals	1,564	484.00	20.31

Summary.

	Feed Given.	Milk Given.	Total Butter Fats.	Lbs. Feed to 1 Lb. Milk.	Lbs. Feed to 1 Lb. Butter.	Lbs. Milk to 1 Lb. Butter.
Dent corn silage (Periods 1 and 3)	2,997	1,002.25	42.71	2.99	70.2	25.5
Sweet corn silage (Period 2)	1,543	511.5	20.42	3.02	75.56	25.5

TABLE LXXVII.—Grand Summary.—Several Kinds of Silage Compared.

Kind of Silage.	Feed Eaten.	Milk Given.	Butter Fat Yielded.	Lbs. Feed to 1 Lb. Milk.	Lbs. Feed to 1 Lb. Butter.	Lbs. Milk to 1 Lb. ButterFat
Group 1—						
Dent corn ensilage	17,036	7,837.25	302.00	2.17	56.4	25.95
Southern ensilage	8,758	3,653.5	137.4	2.4	63.7	26.6
Group 3—						
Dent corn ensilage	8,781	2,571.00	108.2	3.4	81.1	23.8
Southern ensilage	4,057	1,241.00	49.5	3.3	82.00	25.1
Group 2—						
Dent corn ensilage	5,960	2,470.25	121.7	2.41	49.00	20.3
Flint corn ensilage	3,336	1,209.75	59.55	2.75	56.00	20.3
Group 4—						
Dent corn ensilage	2,997	1,002.25	42.71	2.99	70.2	23.5
Sweet corn ensilage	1,543	511.5	20.42	3.02	75.56	25.5

5. This large corn will yield much feed if planted in drills thirty-six to forty inches apart, the stalks averaging six to eight inches apart in the row. It can be planted by means of the ordinary grain drill, using only two or three of the hoes or shoes. The surface of the ground should be well pulverized before planting and the grain put in from two to four inches deep, approaching four inches deep for late planting or on droughty land, and two inches deep for planting early, or on wet, cold land. The corn should be dragged every few days with a slanting tooth or a Scotch harrow until four or six inches high. To allow for the harrow taking out a few plants, in going over four or five times, plant something like one-tenth more seed than sufficient to make the plants as thick as desired. When the harrow must be laid aside cultivate medium shallow with two-horse cultivator, say two inches deep next to the row and three inches deep in the middles between the rows, working a little dirt toward the drills each time. Three or at most five times over with the cultivator is all the cultivation needed after thorough harrow work.

6. Where, as on most of our Minnesota farms, it is desired to clean more land of its weeds with a clean corn crop, and where so much mill feed cannot well be fed with the silage (or corn stover), it pays to grow in hills for silage or for stover and grain, *varieties of corn that will nearly or quite mature so as to get more grain.*

7. To raise this corn for grain and stover or silage and to keep weeds from growing, plant on land well pulverized in spring to a depth of three or four inches—preferably fall plowed six or seven inches deep. Plant with two-horse check row planter or by means of a check-off marker. Hand planting or hoe planting, if intelligently done (getting seed below the drag teeth) is nearly as good. Plant three to five grains in hills forty-two to forty-five inches apart each way. Harrow every three to five days until four to six inches high, as this is a cheap way to keep hills free of weeds. Cultivate two to four inches deep three or four times with level or ordinary cultivator of some kind. Use care to not seriously prune the roots. At each cultivation work a little soil around the hills to kill weeds just starting there.

8. Use the corn in the rotation to prepare the land for wheat or other crop of small grain. Corn gets great good and no harm from fresh manure plowed under, thus enabling the farmer to rot his manure in the soil where it is all saved. Manure should be scattered thinly, so it will go over more land, do more good and no injury to following crops of wheat or oats.

IMPROVED VARIETIES OF CORN.

Three varieties of dent corn have been grown for a few years with a view of distributing them for seed. Each year these varieties are being carefully improved by selection. A limited amount of this seed is now on hand, and will be distributed or used as seed for producing larger quantities for seed another year. In Bulletin No. 11 was given a plan for improving dent and flint varieties for ears and stover combined. While it is of importance that the experiment station find, improve and furnish or sell seeds to farmers, it is of far greater importance to show farmers of each section how to find profit in improving corn and selling seed of improved kinds. The essential facts in selecting corn may be stated as follows: Procure from the experiment station or elsewhere, possibly from your own farm or from a neighbor farmer, a kind that yields well. It may pay to try several promising kinds and select only the best. To do this get a peck or more of seed of each kind and the first year plant only a few rows of each, saving most of the original seed pure with which to start the second year. The varieties growing together in trial plots become badly mixed by the pollen blowing from the tassels of one variety to the silks of another. The grain is the valuable product in most parts of the state. The ear, like the cow's udder, is the organ that must be intensified, and we can change this more rapidly than we can the cow's udder, since we have every year a new generation from which to make selections. Out of the chosen variety select the best ears for seed. Plant in rich fields thirty or more rods from other corn. Manure the land well, fall plow thoroughly, prepare the seed bed in fine condition, plant early, rather thinly and cultivate well, but not too deeply.

When the tassels begin to form destroy all of them on weak plants or those promising only small ears, by pulling the tassels out before they have scattered pollen. This insures that pollen only from good stalks furnishes the pollen for all ears.

When nearly ripe go through with basket and husk off all the best ears, saving out the choicest ears from the choicest stalks. Thus select the ears in two classes, that for general planting, and the choicest for the next year's seed corn patch to be again selected in the same manner.

Pick seed from standing corn, paying attention to larger size or especial earliness as seems wisest, as the earliest plants are not always the best yielding plants. Select especially for large yielding

plants and choose those as nearly true to one type as may be, though do not put type above yield of grain, as this is the quality of greatest value. In a few years the ears and stalks can be reduced to great uniformity. Select large, well formed, solid ears with deep grains, and, if a dent variety, with cob large enough to carry a good number of rows. Fire dry the seed and place where it will keep perfectly dry till planting time. The seed corn patch should be one or several acres and should be located thirty or more rods from other fields of corn.

CORN CULTIVATION.

During several years past experiments on the cultivation of corn have been under way. A part of this work has been reported upon in bulletins Nos. 5 and 11. Plot tests with implements have been made. The effect of pruning the roots with a narrow, strong knife has been investigated, and studies of the root system have been made. Listing has been tried. The varieties best adapted to each purpose have been studied and methods of the improvement of some of the best kinds have been well begun.

PRUNING THE ROOTS OF CORN.

In 1889 a number of plots of corn were rather severely root pruned, and as compared with the alternate rows not pruned, twelve and one-half bushels per acre less of corn was produced. The same experiment was tried again in 1890, and also in 1891. The pruning was done by running a strong butcher knife blade, set in a runner so that it would penetrate the ground four to six inches and be drawn through the soil a few to several inches, either side of the hill without much disturbance of the soil. The following tabular statements show the results for several years. All the corn was cultivated shallow with Tower's cultivator, and as alternate single rows or alternate two rows make up the plots comparing pruned and unpruned, the plots are assumed to be alike in all respects except as affected by the pruning.

TABLE LXXVIII.—Root Pruning Corn in 1889.

Plot.	Grains.		Fodder.	
	Pounds.	Bushels per Acre.	Pounds.	Tons per Acre.
1 Pruned four times	284	34	255	1 1-6
2 Not root pruned	401	48	375	1 4-6
3 Pruned three times	253	30¼	300	1 2-6
4 Not root pruned	417	50	305	1 2-6
5 Pruned two times	326	39	300	1 2-6
6 Not root pruned	402	48¼	400	1 5-6
7 Pruned once	308	37	340	1 3-6
8 Not root pruned	399	48	350	1 3-6
Average root pruned plots	292	35	299	1 1-3
Average of plots not root pruned	405	48½	357	1 3-5

NOTE.—Once pruning means that at the time of plowing the knife passed on either side of the pruned rows, going five inches deep six inches away from the hill. Twice pruning means that the pruning was done the sesond time when the corn was cross plowed and three or four means that the pruning was done at the third and fourth times over with the cultivator.

TABLE LXXIX.—Root Pruning Corn in 1890.

	Grain on Plots, Lbs.	Decrease Lbs. per Plot by Pruning.	Decrease of Grain per Acre Bus.	Fodder on Plot, Bundles.	Decrease by Pruning, Lbs.	Decrease of Fodder per Acre.
1 Pruned four times four inches deep and five inches away from hill	660	90	4	1,660	60	180
2 Not root pruned	750	.....	.....	1,720	.....	.....
3 Pruned four times four inches deep and three inches away from hill	898	32	1½	1,880	170	510
4 Not root pruned	930	.....	.....	2,050	.....	.....
5 Pruned at second and third plowing six inches away and six inches deep	855	15	½	1,860	50	150
6 Not root pruned	870	.....	.....	1,910	.....	.....
7 Pruned both ways at third plowing five inches away and five inches deep	765	75	3¼	1,610	315	945
8 Not root pruned	840	.....	.....	1,925	.....	.....
9 Pruned one way at fourth plowing six inches away and six inches deep	830	55	2½	1,770	155	465
10 Not root pruned	885	.....	.....	1,935	.....	.....
Average loss from root pruning	.....	.....	2½	.....	.....	¼ ton

TABLE LXXX.—Root Pruning Corn in 1891.

	Pounds Grain on Each Plot.	Decrease by Pruning.	Pounds Fodder on Each Plot.	Gain and Loss from Pruning.
3 { 1a. Pruned five inches deep and six inches away	475	—15	335	+60
3 { 2b. Not root pruned	490	.....	275	.....
5 { 3a. Pruned five inches deep and four inches away	500	20	325	—85
5 { 4b. Not root pruned	520	.....	410	.....

The following tabular statement shows results obtained for the three successive years in pruning corn with a shallow-going implement and kept free of weeds:

TABLE LXXXI.—Summary Root Pruning Corn.

		1889.		1890.		1891.	
		Yield.	Loss.	Yield.	Loss.	Yield.	Loss.
Grain, bushels per acre	Root pruned	35	13	34⅓	2⅓	41⅓	1⅔
	Not root pruned	48	.....	26⅔	.....	43⅓	.....
Stover T., per acre	Root pruned	1⅓	4-15	2⅝	¼	1	.....
	Not root pruned	1 3-5	.....	2⅞	.....	1	.....

In another trial in 1889, four bushels less per acre were grown on plots pruned as compared with those not pruned. The most striking injury to the crop is observed for the first of the three years. During 1890 and 1891, however, only a few bushels less of corn and about the same relative amount of stover were grown on the plots where root pruning was done than on those not pruned. The pruning was not quite as severe in 1890 and 1891 as the first season. The only other differing conditions observed were that the soil was comparatively dry when the pruning was done in 1889, and there was a fair or abundant amount of moisture during the other two years at the time of cultivating. Corn certainly has a wonderful power to send out new roots to replace those cut off. As the pruning did no good in any year and did very great injury on many of the plots, the evidence on the whole is in favor of not cultivating the corn deeply close to the plants. On the other hand, very shallow cultivation is not advisable, as a small per cent of the roots can be broken without as serious results to the crop as allowing weeds to grow and leaving too thin a blanket of loose earth that will not last and serve all season as a dirt mulch. The better way is to cultivate two or three inches, or rarely, where many weeds are to be covered, let the cultivator go four inches deep in the middles between the rows. By following the above rule as to depth and by hilling up the corn half an inch or an inch at each plowing the shovels next to the row may be slightly raised each succeeding time of cultivating the corn. This will avoid going deep near the hill.

HILLING CORN.

In 1889 two plots of corn, which had been kept level the fore part of the season with Tower's cultivator, were hilled up by means of a hoe at the last cultivation. Their average yield was just the same as plots made up of the alternating rows which were not hilled.

In 1890 a trial gave an average difference of less than one bushel per acre in favor of the hilled corn and 250 pounds more of fodder per acre on the plots not hilled.

In 1891 the amount of fodder was the same on hilled plots and on plots not hilled, while the plots not hilled had two and one-half bushels per acre more of grain.

In so far as the effect on the yield is concerned hilling of itself seems to have little or no influence where the weeds are kept down on all plots. As a means, however, of destroying newly started weeds, moderate hilling is an aid. At each cultivation half an inch or an inch of loose dirt worked in around the plants does much to smother the Pigeon Grass and other newly started weeds which come up in and near the hill. By regarding hilling as simply a means of killing weeds, the plowman will better handle his cultivator or hoe than if he thinks it for some other purpose. Hilling to more than three or four inches above the general level is often unwise, as the land is thus left very rough for seeding to a succeeding crop.

CORN CULTIVATOR TRIALS.

The subjoined tablar statement gives the figures developed during a trial of corn cultivators. In 1888 a piece of land was divided in twenty-four one-tenth acre plots, and each of the cultivators named in the table was used in cultivating two or more of them. Alleyways between each plot allowed of turning without treading down the corn in the plots proper. In 1889 the entire field was cultivated uniformly with one implement, Tower's surface cultivator, and the yield of corn and fodder for each plot was determined. In 1890 the various implements were again used on the same plots as in 1888. And the table, besides giving the relative yields of each plot, gives also a comparison of the yields when cultivated with the several implements as compared with their yield during the intermediate year when all were planted and cultivated alike. Even a plot test made in this way is not always satisfactory to one who constantly observes the growth of the crops. In many cases there

was far more apparent difference in the corn on different parts of the same plot than on the different plots. The table shows especially well for Tower's surface cultivator, Robert's blades and Weir's tongueless cultivator.

TABLE LXXXII.—Comparison of Corn Cultivators.

	1888.	1890.	Average for First and Third Years When Differently Cultivated.	Yield 1889 When All Were Cultivated Alike With Tower's Cultivator.	Gain or Loss Compared with Intermediate Year, Bushels per Acre.
Bushels grain per acre—					
Robert's Blades	51	52½	51¾	43¾	8
Weir's Tongueless	47	53	50	44¾	5¼
Rotary Disk	42	46½	44¼	45¾	—1½
Tower's Surface	49	61	55	45	10
Bash Surface	45	51	48	51	—3
Tons fodder per acre—					
Robert's Blades	3¼	3¾	3½	2⅜	1⅛
Weir's Tongueless	3	3¾	3⅜	2⅛	1¼
Rotary Disk	3	3½	3¼	2⅛	1⅛
Tower's Surface	3	2¾	2⅞	2	⅞
Bash Surface	3½	3 1/10	3⅗	2⅛	1½

Tower's surface cultivator and Robert's blades cultivated the land medium shallow, but well. Weir's tongueless cultivator has the ordinary two shovels on a side, like the old-fashioned double shovel cultivator, and with it the soil was cultivated in grooves four to five inches deep, as is the custom with most farmers.

In 1891 Mr. Andrew Boss, foreman, cultivated every two alternate rows with Weir's tongueless and Tower's surface cultivator, with the following results:

TABLE LXXXIII.—Weir's Tongueless vs. Tower's Surface Cultivator.

	Lbs. Grain on Plot.	Gain by Deep Cultivation.	Lbs. Fodder on Plot.	Loss by Deep Cultivation.
1. Weir's cultivator, deep shovels, five inches deep and two and one-half inches away each side	560	65	385	40
2. Tower's cultivator, shallow	495	.....	425	.....
3. Weir's, three inches deep and four inches away either side	495	.....	380	.....
4. Tower's cultivator, shallow	495	.....	380	.....

In 1891, in a field of corn, the alternating pairs of rows were treated as shown in Table LXXXIV. This shows slightly better yields of grain for Weir's than Tower's cultivator in one of the two comparisons, and just the opposite is true of the yields of stover for deep than for the shallow cultivating, while the yield of stover was about the same. Pruning, however, in both trials resulted in lessening the yield of grain, and averaging the two trials the yield of stover was about the same. A slightly lessened yield of grain resulted where the corn was hilled high around the stalks as compared with plots where the soil was cultivated level, but the yield of stover was about the same. The plot on which the "aerial," or brace roots, were cut yielded considerable more of grain and slightly more of stover than the compared plot not so pruned.

TABLE LXXXIV.—Cultivation, Depth, Pruning Roots, Hilling, Implements. 1891

Plot.	Pruned. Hilled.	Weight of Corn.	Weight of Stover.
1	a. Weir's deep shovel, five inches deep and two and one-half inches away each side	560	385
	b. Tower's	495	425
2	a. Weir's deep shovels, three inches deep and four inches away on either side	495	380
	b. Tower's	495	380
3	a. Pruned five inches deep and six inches away either side with knife	475	335
	b. Not pruned	490	275
4	a. Hilled six inches high around stalk	530	340
	b. Not hilled	560	345
5	a. Pruned once five inches deep and four inches away either side with knife	500	325
	b. Not pruned	520	410
6	a. Brace roots cut	640	430
	b. Brace roots not cut	545	420

The table below shows the relative adaptability of the different cultivators to keep corn planted in various ways free of weeds as reported in Bulletin No. 5. The land was rather foul with weeds, none of which were removed except as each cultivator succeeded in destroying them, and notes were taken after the second, third, and fourth times the plots were gone over with the cultivator.

By using a "v" or trough-shaped fender made of a six-inch and a seven-inch board, each four feet long, and dragged upside down by a string over the row of young corn the first and second times, Tower's cultivator, the spring tooth cultivators and the Bash surface cultivator did especially fine work in listed corn. Listed corn, however, can be successfully cultivated with any of the implements above mentioned.

TABLE LXXXV.—Effectiveness of Each Cultivation in Keeping the Plots Clean of Weeds Expressed in Per Cent.

	Hills Cultivated, Deep.	Hills Cultivated, Shallow.	Drilled.	Listed.
First and second cultivation—				
Weir's Tongueless	98	88	90	80
Rotary Disk	.....	90	85	80
Tower Bros	.....	95	95	75
Bash Surface	.....	80	75	95
*Bash Surface	.....	90	90	80
Third cultivation—				
Weir's Tongueless	98	90	90	85
Rotary Disk	.....	95	95	80
Tower Bros	.....	95	95	80
Bash Surface	.....	78	75	80
Robert's Blades	.....	98	90	90
Fourth cultivation—				
Weir's Tongueless	98	90	88	90
Rotary Disk	.....	98	88	88
Tower Bros	.....	98	88	88
Bash Surface	.....	80	75	75
Robert's Blades	.....	98	92	90

The several cultivators were used in the fields on the station farm and were tried in soddy land, in corn stalk land, as well as in stubble land and some were used in cultivating potatoes and other crops, thus giving them a general comparison. Lehr's spring tooth cultivator was secured too late to enter all the competitive trials above mentioned.

It has five spring tooth shovels on either side, the spring teeth or shovels being patterned after those on the common spring tooth harrow. The Albion eagle claw, having four spring beams on either side, with two-inch wide shovels instead of the spring forming part of the shovel, was also procured. Owing to a loss of some parts and a delay in transit, this excellent implement was not carefully tested. The Conkling automatic cultivator, with three shovels on a side, proved to be an improvement over the implements with two shovels on a side.

As compared with the ordinary corn cultivator, having two shovels on a side, I feel justified in saying that we have cultivators which do not so seriously prune the roots, but do cultivate the corn quite as well. Those on the spring tooth plan and the Tower's surface cultivator will as effectually clean out the weeds, if the land has been properly prepared before planting, as will those of the double shovel pattern. These cultivators are not quite as useful as the double shovel pattern for other uses on the farm, but where the farmer

has a good pulverizer, like a Disk harrow, he rarely needs his two-horse corn cultivator except for summer tillage. The cultivators, with four or five small shovels on a side, gave best all around satisfaction.

LISTING CORN.

Listing corn as compared with planting on level ground has been tried two years. A number of plots each year were cultivated with the different cultivators here for trial in comparison with plots planted on level ground. In no case did a single plot of the listed corn yield as much as the plots drilled or hilled beside it. On the average the crops were about ten per cent less than the crops on land not listed. We simply repeat our statement made after experimenting with listing corn here in 1888 that, "This method is adapted to dry, warm countries, as Kansas, where much of the corn is planted with the lister, but here at the north we want the seed and roots near the top of the ground. Some dry seasons in the southwestern part of the state this method might prove best, and further trials will be given."

WHEATS—VARIETY TESTS AND IMPROVEMENT OF VARIETIES.

In 1889 the Minnesota Experiment Station began the collection and testing of varieties of spring wheats from all localities where we might expect to find kinds suited to our climate and soils. Prof. D. N. Harper and the writer collected about 150 samples, most of them being small mail samples. Through the assistance of the American consuls in Russia and Hungary, many samples of wheats were secured from those countries. Prof. Wm. Saunders, Ottawa, Canada, director of the Dominion experiment farms of Canada, and Mr. S. A. Bedford, superintendent of the Manitoba experiment farm, Brandon, made material additions to the list. Mr. C. A. Zavitz, of the Ontario agricultural college, Guelph, and Prof. Luther Foster, then at South Dakota agricultural college, also Prof. James Wilson, of Iowa agricultural college, Ames, gave us a number of wheats for trial. The 150 samples first collected were planted in 1890 at War-

ren, Marshall county, on lands belonging to Messrs. March and Spalding. This land is typical Red River Valley soil. The rainfall was sufficient for only a moderate crop in the neighborhood. The varieties were grown in such small plots that no yields were recorded. Some kinds proved to be winter wheats, and others were of such inferior quality that they were at once discarded. Samples of all the better kinds were harvested by hand, and these, with others collected later, were sown in 1891 at Glyndon, Clay county, ten miles east of Moorhead and Fargo, on the farm of Mr. J. Buckham. A fire, which burned the station laboratory during the fall of 1890, has destroyed letters and other records giving the names of the various kinds of wheat received from Russia and other foreign countries. Consequently, in 1891, the records of each kind were made by using the name of the town where they were planted and our original laboratory entry number, thus: Glyndon 676, or abbreviated to "G. 676."

The land chosen at Glyndon was a sandy loam. It had grown a dozen or less crops of wheat, and the year before was manured and bore a crop of potatoes. The seed was sown in narrow long plots with a Superior shoe press drill on the well prepared soil and as the land had few weeds, all varieties were given an equal chance. The harvesting was carefully performed by means of hand sickles, and threshing was done with flails. In 1892 and 1893 all the best wheats grown at Glyndon in 1891 were grown by the writer, at the North Dakota experiment station at Fargo, together with other varieties of spring wheat collected from various sources. Prof. J. H. Shepperd, of that institution, again grew the most promising varieties in 1894. The soil at Fargo is typical of the Red River valley, and all three years the fields of wheat in the vicinity were below the average for the past decade. In 1894 Mr. T. A. Hoverstad grew all the best of these varieties on good land at our Coteau subexperiment farm in Lyon county, and thirty-three of them were grown by the writer on Rev. S. Currie's farm at Euclid, Polk county, Minn., fifteen miles north of Crookston, on good Red River valley land.

In Table LXXXVI. are collected part of the facts relative to the yields of the most promising of the more than 200 kinds of wheats we used in these several tests. Some of these have now been in six or seven variety tests, at Warren, in 1890; Glyndon, 1891; Fargo, 1892, 1893 and 1894; and at Euclid and at Coteau Experiment Farm in 1894.

University Number.	Variety.	Source.	Bearded or Smooth.	Days Maturing.	Grade at Fargo, 1892.	Grade at Fargo, 1893.	Grade at Coteau, 1894.	Yield at Glyndon, 1891	Yield at Fargo, 1892.	Yield at Fargo, 1893.	Yield in 1894.			Average Yield in the Six Tests.	Weight per Bushel at Coteau, 1894.
											Fargo.	Coteau.	Euclid.		
1¼	Blue Stem	W. R. Gregg	S	89	.....	.....	2 N.	.....	.....	.....	.....	14.9	.....	14.9	53½
1½	Power's Fife	North Dakota Agricultural College	S	89	.....	.....	1 H.	.....	.....	.....	.....	17.4	.....	17.4	54
1½	Hayne's Blue Stem	North Dakota Agricultural College	S	91	.....	.....	2 N.	.....	.....	.....	.....	12.7	.....	12.7	54
3	Champlain	Brookings	B	89	2 N.	2 N.	1 H.	.....	17.00	13.0	.....	17.8	.....	15.9	60
4	Golden Drop	Brookings	S	89	3 N.	2 N.	1 N.	.....	15.00	13.5	.....	9.1	.....	12.5	56
6	Campbell's White Chaff	Brookings	S	91	Rej.	Rej.	1 N.	.....	16.33	6.0	.....	17.4	.....	13.2	57
8	Blount's Hybrid No. 17	Brookings	B	91	3 N.	3 N.	2 N.	.....	20.66	11.6	.....	16.7	.....	16.3	57
9	Snowball	Brookings	S	91	2 N.	1 N.	1 N.	.....	33.33	13.7	.....	21.5	.....	22.8	58
10	Kubanka	Brookings	B	91	Rej.	Rej.	Rej.	.....	19.85	13.7	.....	21.3	.....	18.3	58½
11	Silver Fife	Brookings	S	92	3 N.	1 N.	.....	.....	14.14	11.2	.....	23.9	.....	16.4	56
12	China Tea	Brookings	B	91	Rej.	Rej.	.....	.....	19.50	11.5	.....	17.1	.....	16.0	56
13	Blount's Hybrid No. 15	Brookings	S	93	3 N.	1 N.	1 N.	.....	17.33	12.8	.....	23.8	.....	17.9	55
14	Okagagon Valley Velvet Chaff	Brookings	S	94	2 N.	1 N.	2 N.	.....	17.50	15.6	12.1	21.59	15.3	16.4	.....
15	Assiniboine Fife	Brookings	S	93	3 N.	1 H.	1 H.	.....	19.97	12.1	10.4	21.33	15.5	15.8	57
16	Red Fern	Guelph	B	91	2 N.	1 N.	1 H.	.....	14.66	12.4	11.6	25.0	.....	15.9	56
19	White Russian	Guelph	S	91	2 N.	1 N.	1 N.	.....	17.66	11.9	.....	23.0	.....	17.6	57
22	Blue Stem	Guelph	S	93	2 N.	1 N.	.....	.....	22.60	11.2	.....	21.0	.....	18.3	54
23	Red Fife	Guelph	S	92	1 N.	1 H.	1 H.	.....	14.33	12.0	11.2	22.6	14.7	14.9	55
25	Pringle's Champlain	Guelph	B	90	2 N.	2 N.	1 H.	.....	16.00	11.9	.....	24.2	.....	17.4	58
27	Assiniboine Bearded	Brandon	B	89	2 N.	2 N.	1 H.	.....	14.66	12.6	.....	23.9	.....	17.1	.....
33	Judket	Brandon	S	92	1 N.	1 N.	1 N.	.....	15.64	11.8	.....	21.4	.....	16.3	57
35	Red Fife	Brandon	S	93	1 N.	1 N.	1 N.	.....	15.66	10.3	.....	20.6	.....	15.5	54
36	French Imperial	Brandon	B	89	2 N.	3 N.	1 N.	.....	17.66	11.8	.....	20.2	.....	16.5	60
37	Summer Cob	Brandon	S	91	1 H.	1 N.	1 N.	.....	17.33	15.4	10.1	22.2	.....	16.2	54½
38	Hungarian Mountain	Brandon	S	90	2 N.	Rej.	1 N.	.....	14.62	11.4	.....	25.8	.....	17.3	59
39	Club	Brandon	S	90	3 N.	Rej.	1 N.	.....	15.00	7.8	.....	14.9	.....	12.5	61
44	Bedford's Hungarian Mountain	Brandon	S	92	1 N.	1 N.	1 N.	.....	14.66	15.3	9.6	22.2	.....	15.4	55
45	Eureka	Brandon	B	90	1 N.	1 N.	1 N.	.....	13.00	12.8	11.6	25.8	.....	15.8	56
49	Campbell's White Chaff	Brandon	S	90	Rej.	Rej.	1 N.	.....	20.86	9.2	.....	19.8	.....	16.6	58
50¼	Power's Fife	North Dakota Agricultural College	S	92	.....	.....	2 N.	.....	.....	.....	.....	26.2	.....	26.2	53½
50½	Hayne's Blue Stem	North Dakota Agricultural College	S	93	.....	.....	.....	.....	.....	.....	.....	21.0	.....	21.0	51
51	Hayne's Blue Stem	Brandon	S	94	1 H.	1 N.	3 N.	.....	16.66	.....	14.8	20.6	.....	17.3	51
51¼	Houston's Blue Stem		S	93	.....	.....	2 N.	.....	.....	.....	.....	15.8	.....	15.8	52
51½	Hayne's Blue Stem		S	94	.....	.....	2 N.	.....	.....	.....	.....	18.7	.....	18.7	51½
52	Colorado	Brandon	B	88	2 N.	Rej.	1 N.	..	19.66	.....	.....	9.1	.....	14.4	60½
52¼	Hard Red Fife (Red Garnet)		S	92	.....	.....	.....	.....	.....	.....	.....	18.6	.....	18.6	56½
52½	Wellman's Fife		S	91	.....	.....	1 H.	.....	.....	.....	.....	14.7	.....	14.7	58½
53¼	Scotch Fife		S	90	.....	.....	.....	.....	.....	.....	.....	16.2	.....	16.2	56
53½	Saskatchewan Fife		S	91	.....	.....	1 H.	.....	.....	.....	.....	17.4	.....	17.4	55

55	Red Fern	Brandon	B	89	1 N.	1 N.	1 H.		15.82	14.6	12.2	21.0		15.9	59
56	Old Red River	Brandon	S	90	1 N.	1 H.	1 N.		20.45	11.9	9.6	17.4	14.7	14.8	54½
58	California White	Brandon	S	93	2 N.	2 N.	1 H.		13.80	9.4		17.1		13.4	56½
66	Power's Fife	Power, North Dakota	S	92	1 N.	1 H.	1 H.		21.23	15.1	12.6	19.8	15.8	16.9	55½
67	McKissick's Fife	Mayville, North Dakota	S	92	1 N.	1 H.			17.33	12.9	11.2	19.8	14.7	15.2	56½
68	Red Fife	Steele Bros.	S	92	1 N.	1 H.	1 H.		18.33	13.4	10.6	18.6	15.2	15.2	55
69	Russian	Steele Bros.	B	90	3 N.	3 N.	1 N.		13.06	8.8		8.3		10.0	59
70	Wild Goose	Steele Bros.	B	92	Rej.	Rej.	Rej.		24.68	15.1	11.6	18.2	17.2	17.3	54½
71	White Fife	Steele Bros.	S	92	1 H.	1 N.	1 N.		19.00	11.9	11.6	19.8	18.1	16.1	55
72	Rio Grande		B	91	2 N.	3 N.	1 N.			13.4		13.6	13.5	13.5	56
73	Glyndon (619)		S	91	3 N.	2 N.	1 N.			6.8		19.9	13.3	13.3	57
74	Glyndon (629)		S	92	1 N.	1 N.	1 H.	28	15.97	11.8		20.3		19.0	55
75	Glyndon (636)		B	90	2 N.	Rej.	1 N.	14	14.4	17.4		19.9		16.4	57
76	Glyndon (638)		S	92	1 N.	1 H.	1 N.	28	13.73	13.8	11.6	18.1	17.0	17.0	55
77	Glyndon (639)		B	89	2 N.	3 N.	2 N.	16	18.88	11.5		15.8		15.5	56
78	Glyndon (650)		S	90	1 H.	1 N.	2 N.		15.94	12.9	10.0	19.8		14.6	54½
80	Glyndon (657)		B	89	Rej.	Rej.	2 N.	20	14.33	4.5		14.2		13.2	56½
83	Glyndon (663)		S	89	3 N.	1 N.	1 N.	9		11.6		18.7		13.1	55
84	Glyndon (664)		S	90	1 N.	1 N.			14.41	13.0	9.8	19.1		14.1	
85	Glyndon (668)		S	89	2 N.	3 N.	1 N.		16.48	10.1		20.3		15.6	58
86	Glyndon (669), 19 at Glyndon, '91		S	90	1 N.	1 H.	1 H.	19	12.25	13.3	10.5	19.1	16.4	15.1	55
87	Glyndon (669), 3 at Glyndon, '91		S	90	1 N.	1 H.	1 H.	36	14.66	11.0	9.5	20.3	16.0	16.2	54
89	Glyndon (668), 4 at Glyndon, '91		S	90	1 N.	1 N.	1 N.	25	12.72	13.7	8.4	19.8		13.3	54
91	Glyndon (670), 35 at Glyndon, '91		S	90	1 N.	1 N.	1 N.	21	21.00	13.6	11.6	20.6	16.9	17.5	57
93	Glyndon (673), 30 at Glyndon, '91		S	90	2 N.	1 N.	1 N.	21	16.66	12.5	9.8	20.6		16.1	54
94	Glyndon (673), 67 at Glyndon, '91		S	89	2 N.	1 H.	1 N.	25	14.21	10.6	11.7	20.3	16.7	16.4	55
95	Glyndon (675), 42 at Glyndon, '91		S	89	2 N.	1 N.	1 N.	35	16.30	9.9		14.9		19.0	53
96	Glyndon (675), 28 at Glyndon, '91		S	89	2 N.	1 H.	1 N.	30	15.00	12.0	10.4	18.3		17.1	54½
97	Glyndon (676)		S	90	2 N.	1 N.	1 N.	31	15.33	12.2	12.6	9.9		18.2	55
99	Glyndon (687)		S	90	1 N.	1 N.	1 N.	23	15.25	11.7		19.9		17.4	54
100	Glyndon (691)		S	89	2 N.	3 N.	1 N.	24	17.66	10.2		23.0		18.7	57½
101	Glyndon (692)		S	90	1 N.	1 H.	1 N.	22	12.33	13.3	12.6	22.2	17.8	16.7	55½
102	Glyndon (694)		S	90	1 N.	1 N.	2 N.	20	13.77	11.3		22.1		16.8	55
103	Glyndon (696)		B	87	2 N.	Rej.	2 N.	26	15.66	11.2		19.0		17.9	57
104	Glyndon (697)		B	87	2 N.	Rej.	2 N.	31	14.31	9.1		19.8		18.5	57
105	Glyndon (711)		S	90	2 N.	1 N.	1 N.	38	23.36	10.0	9.7	21.4	16.0	19.7	54
106	Glyndon (715)		S	91	1 N.	1 N.	1 N.		16.80	12.8	11.2	23.0		15.9	54
107	Glyndon (747)		S	91	1 N.	1 H.	1 N.	18	14.13	13.2	10.0	22.2	17.3	15.8	55
109	Glyndon (748), 12 at Glyndon, '91		S	92	3 N.	1 N.	1 N.	19	16.66	14.0	9.5	23.2		16.5	53
110	Glyndon (852)		S	92	1 N.	1 N.	1 N.		16.66	14.8	14.6	21.8	14.3	16.4	54½
112	Glyndon (750)		S	92	3 N.	1 N.	1 N.	28	16.00	14.6	13.5	24.2	17.2	18.9	53
113	Glyndon (754)		S	92	1 N.	1 N.		23	17.66	11.5		20.0		18.0	53½
115	Glyndon (758), 66 at Glyndon, '91		S	91	2 N.	1 N.	1 N.	17	14.00	12.8	9.6	19.8		14.6	54
116	Glyndon (758), 53 at Glyndon, '91		S	91	2 N.	1 N.	1 N.		14.66	14.3	15.3	19.3	17.2	16.1	53½
117	Glyndon (761)		S	91	1 N.	1 N.		32	15.00	11.0	14.6	21.0	13.7	17.9	53½
118	Glyndon (768)		S	91	1 N.	1 H.	1 N.	20	13.38	13.1	13.3	19.4	16.1	15.9	54
119	Glyndon (773)		S	91	1 N.	1 N.	1 N.	19	17.66	11.6		17.8		16.4	54
120	Glyndon (774)		S	91	1 N.	1 H.	1 N.	23	12.33	12.6	11.0	19.8	14.8	15.6	55½
121	Glyndon (775)		S	91	1 N.	1 N.	1 H.	25	13.00	12.7	10.8	19.8		16.2	55½
122	Glyndon (794)		B	85	Rej.	Rej.	Rej.	36	19.25	13.1	12.9	19.8	15.2	19.4	57½
124	Glyndon (815), 8 at Glyndon, '91		S	90	1 N.	1 N.	1 N.	22	13.33	10.3	14.6	19.8		16.0	55½
125	Glyndon (815), 15 at Glyndon, '91		S	90	1 N.	1 H.	1 N.	30	15.00	14.5		22.2	14.9	19.3	56

TABLE LXXXVI.—Continued.

University Number.	Variety.	Source.	Bearded or Smooth.	Days Maturing.	Grade at Fargo, 1892.	Grade at Fargo, 1893.	Grade at Coteau, 1894.	Yield at Glyndon, 1891.	Yield at Fargo, 1892.	Yield at Fargo, 1893.	Yield in 1894.			Average Yield in the Six Tests.	Weight per Bushel at Coteau.
											Fargo.	Coteau.	Euclid.		
127	Glyndon (815), 13 at Glyndon, '91		S	89	3 N.	3 N.	1 N.	30	20.10	10.2	10.6	19.8	14.4	17.5	58½
128	Glyndon (818), 16 at Glyndon, '91		S	90	2 N.	1 N.	1 N.	20	13.19	12.5	8.8	17.8	.....	14.4	56
132	Glyndon (963)		S	90	2 N.	1 N.	1 N.	9	17.33	13.6	10.6	18.6	.....	13.8	55½
133	Glyndon (964)		S	90	3 N.	1 N.	1 N.	25	17.50	12.0	.....	17.5	.....	18.0	55½
134	Glyndon (3001)		B	89	2 N.	2 N.	1 N.	22	17.60	15.5	14.8	19.3	.....	17.8	58
135	Glyndon		S	90	2 N.	1 N.	1 H.	.....	16.50	14.4	10.6	19.8	.....	15.3	54½
137	Poorest one-third Fife at Glyndon		S	90	1 H.	1 N.	1 N.	.....	10.00	15.2	11.0	19.8	14.4	14.1	55
138	Medium one-third Fife at Glyndon		S	90	1 H.	1 N.	1 N.	.....	14.33	10.8	10.9	20.2	.....	14.0	54½
140	Anglo-Canadian		B	92	2 N.	1 N.	1 N.	.....	.....	11.9	.....	20.2	.....	16.0	53½
143	Wellman's Fife		S	89	.....	1 N.	1 H.	.....	.....	12.1	10.6	18.2	15.2	14.0	53½
145	Ladoga		B	92	.....	3 N.	.....	.....	.....	9.2	12.3	.....	.....	10.7	.....
146	Bolton's Blue Stem		S	91	.....	1 N.	.....	.....	.....	17.8	.....	21.4	15.3	18.1	49
147	Houston's Blue Stem		S	92	.....	.....	.....	.....	.....	.....	.....	19.8	.....	19.8	.....
148	Houston's Blue Stem		S	92	.....	.....	.....	.....	.....	.....	.....	19.4	.....	19.4	49

BEST VARIETIES OF WHEAT SELECTED FOR PROPAGATION AND DISTRIBUTION.

In Table LXXXVII. are collected the facts relating to twenty-two of the varieties which have averaged best in all these tests. The three first in the table yielded best on the average for six yields running over four years. The next five yielded best of those five times in the variety tests. The next six were the best of those grown four times. The next group of eight were the best yielders grown at Fargo in 1892 and 1893 and at Coteau farm in 1894. We have shown in the table the yields of Fife No. 66, and of two stocks of Blue Stem Nos. 51 and 146, grown for comparison with the new wheats. Other samples of Fife grown at different times in comparison did not yield as large yields as the sample or "stock" known in our notes as "Power's Fife." This Fife was really orignated a decade ago from a single plant by Mr. James Holes of Fargo, N. D., and shows what a little effort at careful selection will accomplish.

These twenty-two varieties are nearly all hard wheats and apparently of good quality. Nearly all of them yielded better than the best selected fife and blue stem which we could find in the Northwest. It is believed that we have here the basis of a number of varieties which will develop into strong rivals of blue stem and fife, now the only wheats grown in considerable quantity in the region of No. 1 hard wheat. These twenty-two varieties are to be planted again, and at least a number of them propagated in quantities sufficient for distribution to farmers for further trial within a few years. The results indicate that most of these wheats will make better yielders than fife and blue stem and be of equal quality, thus keeping up our record for No. 1 hard wheat.

The grading of these wheats was done by Mr. Tunnell, deputy state grain inspector, Minneapolis, and by Mr. Henderson of the Fargo Roller Mills, Fargo, N. D. Many of the wheats coming from Russia seem to be of the same specific character as our red fife, known over the Northwest as Scotch fife, and by other similar names. The tradition is that this wheat came to the Northwest many years ago by Scotch Canadians getting small samples from Russia. Our experience with wheat picked up by consuls in the Russian markets confirms the belief that our class of wheats known as fife, Scotch fife, or red fife, came to us originally from Russia. Of the first lot of wheats marked in the notes as Glyndon, or "G 676," except the smooth white chaffed kinds, which in berry, straw and spike resemble fife, comparatively few have been found worthy to keep in the trials for more than a year or two. While we shall

TABLE LXXXVII.—Wheat—Varieties Selected for Further Propagation and Distribution.

Best Yields of Varieties Tested Six Times.

University Number.	Variety.	Height.	Length of Head.	Bearded or Smooth.	Color of Chaff.	Chaff Velveted or Smooth.	Days Maturing.	Chaff Holds.	Weight per Bushel.	Yield, 1891.	Grade.	Yield, 1892.	Grade.	Yield, 1893.	Grade.	Yield at Euclid, 1894.	Grade.	Yield at Coteau, 1894.	Grade.	Yield at Fargo, 1894.	Grade.	Average Yield.	Average Grade.
105	Glyndon, 711	33	2.5	S.	W.	.....	92	Good.	51	38	.....	23.33	2 N.	10.0	1 N.	16.0	1 N.	21.4	1 N.	9.7	.....	19.7	.....
112	Glyndon, 750	35	3.0	S.	W.	.....	94	Medium.	52	28	.....	16.00	3 N.	14.6	1 N.	17.2	1 N.	24.2	1 N.	13.5	.....	18.9	.....
76	Glyndon, 638	30	2.7	S.	W.	.....	92	Medium.	53	28	.....	13.73	1 N.	13.8	1 H.	17.0	1 N.	18.1	1 N.	11.6	.....	17.1	.....

Best Yields of Other Varieties Tested Five Times.

125	Glyndon, 815	31	2.5	S.	W.	.....	92	Good.	54	30	.....	15.00	1 N.	14.5	1 H.	14.9	2	22.2	1 N.	.....	.....	19.3	.....
96	Glyndon, 675 (28 at G., 1891)	33	2.7	S.	W.	.....	91	Medium.	51	30	.....	15.00	2 N.	12.0	1 H.	.....	.....	18.3	1 N.	10.4	.....	17.1	.....
66	Power's Fife	31	2.7	S.	W.	.....	.....	Good.	55	.....	.....	21.33	1 N.	15.1	1 H.	15.8	1 H.	19.8	1 H.	12.6	.....	16.9	.....
...	Glyndon, 758	35	2.7	S.	W.	.....	93	Medium.	54	.....	.....	14.66	2 N.	14.3	1 N.	17.2	1 N.	19.3	1 N.	15.3	.....	16.1	.....
71	White Fife	32	3.0	S.	W.	....	92	Medium.	53	.....	.....	19.00	1 H.	11.9	1 N.	18.1	1 N.	19.8	1 N.	11.6	.....	16.1	.....

Best Yields of Other Varieties Tested Four Times.

95	Glyndon, 675	33	2.3	S.	W.	.....	91	Medium.	51	35	.....	16.3	2 N.	9.9	1 N.	.....	.....	14.9	1 N.	.....	.....	19.0	.....
74	Glyndon, 629	31	3.0	S.	W.	.....	91	Good.	58	28	.....	15.79	1 N.	11.8	1 N.	.....	.....	20.3	1 H.	.....	.....	18.9	.....
100	Glyndon, 691	32	2.7	S.	W.	.....	91	V. Good.	56	24	.....	17.66	2 N.	10.2	3 N.	.....	.....	23.0	1 N.	.....	.....	18.7	.....
104	Glyndon, 697	35	2.7	B.	R.	.....	89	Medium.	55	31	.....	14.31	2 N.	9.1	Rej.	.....	.....	19.8	2 N.	.....	.....	18.5	.....
113	Glyndon, 754	36	2.7	S.	W.	.....	94	Medium.	54	24	.....	17.66	1 N.	11.5	1 N.	.....	.....	20.0	.....	.....	.....	18.1	.....
99	Glyndon, 687	32	2.5	S.	W.	.....	92	Good.	54	23	.....	15.25	1 N.	11.7	1 N.	.....	.....	19.9	1 N.	.....	.....	17.4	.....

Best Yields of Other Varieties Tested Three Times.

9	Snowball	34	3.5	S.	W.	.....	91	Poor.	55	.....	.....	33.33	2 N.	13.7	1 N.	.....	.....	21.5	1 N.	.....	.....	22.8	.....
72	Rio Grande	33	3.7	S.	W.	.....	93	Good.	51	.....	.....	22.6	2 N.	11.2	1 N.	.....	.....	21.0	.....	.....	.....	18.2	.....
146	Bolton's Blue Stem	.....	.....	.....	.....	.....	94	.....	....	.....	.....	.....	.....	17.8	.....	.....	.....	21.4	.....	15.3	.....	18.1	.....
13	Blount's Hybrid No. 15	32	3.3	S.	W.	.....	93	Medium.	55	.....	.....	17.33	3 N.	12.8	1 N.	.....	.....	23.8	1 N.	.....	.....	17.9	.....
51	Haynes' Blue Stem	39	3.5	S.	W.	.....	94	Poor.	54	.....	.....	16.6	1 H.	.....	.....	.....	.....	20.6	3	14.8	.....	17.3	.....
19	White Russian	32	3.7	S.	W.	.....	91	Good.	54	.....	.....	17.66	2 N.	11.9	1 N.	.....	.....	23.0	1 N.	.....	.....	17.6	.....
25	Pringle's Champlain	31	3.0	B.	W.	.....	.....	Good.	55	.....	.....	16.00	2 N.	11.9	2 N.	.....	.....	24.2	1 H.	.....	.....	17.3	.....
27	Assiniboine Bearded	36	2.5	B.	R.	.....	.....	Medium.	55	.....	.....	14.66	2 N.	12.6	2 N.	.....	.....	23.9	1 H.	.....	.....	17.1	.....

continue to welcome new, promising foreign spring wheats for trial, we shall henceforth direct our energies more to the improvement of those we already have and which have proved best adapted to our conditions. We have been a little disappointed that one or more of the 200 varieties and over which we have sown did not show much larger average yields. Even if we could find a soft wheat which would yield five bushels more per acre than the kinds we now grow we should find profits in raising it, as the income of money per acre would be more than we now get for our famous, but rather low yielding, hard wheats. We would heartily welcome a large yielding soft spring wheat for consumption and to sell for feed. Some of these new varieties have averaged one to three bushels per acre more than fife or blue stem, but their milling qualities are yet to be tested. Our farmers certainly do not wish to give up the idea that present yields of wheat in Minnesota are all that an intelligent people should hope for from our rich soils, while Eastern farmers are securing fifty to one hundred per cent better yields on their worn lands to which commercial fertilizers must be supplied. Wise systems of rotations, so managed that wheat will be grown only on lands especially prepared for it, either by cultivation or kind of crop raised, as grass, etc., do much to bring up averages and give us more clear profits. As noted elsewhere in this report we are starting extensive experiments to find out and illustrate the best ways of managing fields to make clear profits at farming. But besides good methods of raising wheat we want the best varieties. If a variety can be found, or if one can be originated, which will increase the average yields only a peck per acre a great object will be accomplished. But an increase of several bushels per acre would mean millions of dollars to our farmers, and this seems within the range of possibilities. For the present, south of the Northern Pacific Railway and in sections north of that line where early frosts do not usually kill late wheat, or on light quick lands, our farmers should use mainly blue stem for seed. Further north it is better to sow fife wholly or partly as it matures early. Where blue stem will ripen it will yield more wheat on the average, and, though it sells for a slightly lower price than fife, it yields more money per acre. Owing to the looseness of its chaff, blue stem is not so well adapted to stand long after it is ripe as is fife, and on the large farms this is sometimes a disadvantage, as the crop cannot always be cut just when ripe. Care in shocking and stacking is also more important with blue stem, as the loose chaff causes it to shell very

readily. Ordinarily the period of ripening is almost as extended as the period of seeding, thus allowing the reaping to be done as fast as the grain ripens. It is more important to cap shocks of blue stem wheat than of fife, because in open shocks the grain, not having close chaff, is bleached by dews and rains. The chaff of fife remains close to the berry, while many of the blue stem grains are more than half exposed to the air by the chaff spreading away. Most of the best wheats in Table B have chaff which holds as well or better than the chaff of fife, as shown by the notes.

In Table LXXXVII. the 22 varieties which yield best are so arranged that they may be compared. Each one of these six tests, except the one in 1891 at Glyndon, has been under conditions where yields have not been large in the neighborhood, and the average of all the yields appears small. Each year some good fife and blue stem wheat, which are well known to all our farmers, have been grown on adjacent plots under like condition to serve as a basis for comparison.

VARIETIES ORIGINATED BY SELECTION.

In 1892 I chose from the varieties of wheat five kinds which had yielded best at Glyndon in 1891, and also the best samples of fife and blue stem obtainable. Four hundred kernels of each kind were selected and each kernel was planted by itself twelve inches apart each way. Thus each plant had ample room, and the same as every other plant. Part of this selected wheat was grown at Fargo, and part at Power, N. D. When in blossom all the plants were inspected and some of the best were chosen to be crossed by hand pollenization. When ripe the plants were again inspected, the number of heads counted, the height of plants and length of heads were recorded, and other features noted. Ten out of each 400 were chosen as the most promising yielders of good wheat. These were harvested and the grain was shelled out of each plant and weighed. It was observed that the variation of the 400 plants was very great. Greater surprise came, however, when the weights of the grain from the ten selected plants were compared. In Power's Fife, for example, the crops of the ten carefully chosen plants ranged from three and one-half to thirteen and one-half grams of wheat per plant, and in other varieties the variation was nearly as great. This selection was begun on the theory that the plants which yield the most wheat are the best from which to originate large yielding varieties. The best yielders of these plants were chosen, and in 1893 one or more hundred kernels from each were planted, a foot

apart each, at Fargo. These plants did not have a uniform chance owing to an unfortunate rain, so that the yields of the rows were not comparable. Some of the best plants were again chosen to carry on further the selection of individual plants, but the most of the wheat from each of the best rows was harvested in bulk. The wheat from thirty-six of these rows was planted with a Dowagiac drill at the university experiment farm in 1894 and was harvested and threshed. The season was so very dry that the quality of all wheat on the university farm was poor. The yields were not large, but none were worse in either respect than wheat grown from the best fife and blue stem under like conditions.

TABLE LXXXVIII.—Wheat, Selected Varieties.

University Number.	Original Stock.	No. of Individual Plant in 1892.	Length of Head.	Height.	Grade, 1894.	Yield in Grains from 1 Kernel, 1892.	Yield in 1894.
147	Power's Fife	108	3	30	2 N.	9.	10.9
148	Power's Fife	108	2½	30	2 N.	9.	11.3
149	Power's Fife	108	3	31	2 N.	9.	11.4
150	Power's Fife	103	3	32	2 N.	13.8	12.8
151	Power's Fife	76	3	32	2 N.	11.8	13.2
152	Power's Fife	76	3¼	33	2 N.	11.8	11.5
153	Glyndon, 818	2476	3	31	2 N.	9.	14.4
154	Glyndon, 818	2540	2¾	33	2 N.	15.5	8.2
155	Glyndon, 818	2540	3	30	2 N.	15.5	14.4
156	Glyndon, 818	2592	3¼	31	2 N.	11.3	17.9
157	Glyndon, 753	1277	3	32	2 N.	11.	18.3
158	Glyndon, 753	1277	3	31	2 N.	11.	16.6
159	Haynes' Blue Stem	501	3½	36	Rej.	18.1	15.
160	Hawan	5014	3	31	2 N.	.....	15.6
161	Haynes' Blue Stem	551	3½	36	Rej.	19.3	15.
162	Glyndon, 753	1326	3	32	2 N.	13.8	16.6
163	Glyndon 811	2001	3	29	2 N.	15.4	33.
164	Wellman's Fife (close groove)	.....	3½	28	3 N.	.....	15.
165	Wellman's Fife (Bradley's close groove)	.....	3½	30	2 N.	.....	12.8
166	Power's Fife	.....	2½	27	2 N.	.....	11.1
167	Glyndon, 761	1701	2¾	27	2 N.	16.	11.7
168	Glyndon, 811	.....	3	28	3 N.	.....	15.3
169	Haynes' Blue Stem	476	3¼	30	3 N.	19.1	15.4
170	Haynes' Blue Stem	476	3	30	3 N.	19.1	12.
171	Hawan	4914	2½	25	3 N.	.....	26.2
172	Wellman's Fife (Bradley's open groove)	.....	3½	31	3 N.	.....	11.3
173	Haynes' Blue Stem	551	3	32	3 N.	19.3	13.3
174	Glyndon, 811	2022	3¼	33	3 N.	6.	12.5
175	Haynes' Blue Stem	476	3¼	33	3 N.	19.1	12.5
176	Glyndon, 761	1695	2¾	30	2 N.	14.7	14.2
177	Haynes' Blue stem (deep crease)	440	2¾	30	2 N.	15.4	16.1
178	Glyndon, 761	1695	3	31	3 N.	10.9	13.6
179	Haynes' Blue Stem	464	3	30	3 N.	16.6	11.4
180	Haynes' Blue Stem	551	3	31	3 N.	19.3	15.8
181	McKendrie's Fife	802	3	29	2 N.	13.	14.2
182	Glyndon, 753	1326	2¾	28	3 N.	13.8	10.7

In Table LXXXVIII. are given the yields and quality of all these wheats. There is no reasonable doubt but that the quality of all will be good if grown under favorable conditions. Column 2 in Table LXXXVIII. gives the name of the variety from which the seed of each

selected variety was chosen, and the number under which it may be found in Table LXXXVI. is given. In column 3 is given the nursery book number of the original individual plant in 1892 at Power, N. D., from which the selected variety sprang.

Again, in 1893, at Fargo the best plants, of many thousand grown a foot apart each way, were chosen from the several hundred of each selected stock found best the year before. Part of these were planted at Fargo by Professor Shepperd in 1894, and he kindly allowed me to bring part to Minnesota that we might co-operate and divide any good varieties thus originated. Numerous new varieties based on a single large yielding plant, separately grown in 1893, are now on hand in quantities large enough to be tested in the field. While most of the varieties secured from various parts of the world are discarded as not so desirable as fife and blue stem, we have originated, by the plan above mentioned, many new varieties. These new varieties are simply selected stocks from our better kinds of wheat. We have still other numerous new varieties which are selected from the results by cross pollenization of different kinds of wheat. But these are not yet produced in quantities sufficient for us to place them in field tests. With a good arrangement of threshing machinery the annual cost of testing each variety is indeed very slight. The plans for improving varieties of wheat and other small grains, which this station is now carrying out, are far more complete and comprehensive than any heretofore recorded in this country, so far as we know. By work no more thorough nor more careful European experimentors and seed growers have so developed sugar beets that, instead of a juice with six per cent of sugar at the beginning, they now have varieties which average twelve to fifteen.

WHEATS—CROSSING AND SELECTING.

Besides originating varieties by selecting, many crosses of wheat have been made. The following general plan has been followed in making most of our crosses: The best plants, growing a foot apart each way to allow all equal development, are chosen from the best stocks, or selected kinds of wheats, using only those which are at the right stage of development to be pollenized. In cross-pollenizing one or more spikes or "heads" are chosen from each of the two kinds to be crossed. All the upper part of the spike is cut away; also a few of the spikelets at the base of the spike. The middle smaller flower of each spikelet is pulled out, thus leaving the strongest pair of flowers on each of six or more spikelets, or in all twelve to twenty

TABLE LXXXIX.—Wheat, Varieties used in Making New and Improved Kinds.

VARIETY.	Height.	Length of Head.	Bearded or Smooth.	Color of Chaff.	Chaff Velveted or Smooth.	Days Maturing.	Chaff Holds.	Weight per Bushel.	Yield, 1891.	Grade.	Yield, 1892.	Grade.	Yield, 1893.	Grade.	Yield, Euclid, 1894.	Grade.	Yield, Coteau, 1891.	Grade.	Yield, Fargo, 1894.	Grade.
Glyndon, 754	36	2.7	S.	W.	S.	92	Medium.	54	23.0	.....	17.66	1 N	11.5	1 N.	.....	.....	20.0	....	.....	.....
Glyndon, 761	35	3.0	S.	W.	S.	91	Medium.	55	32.0	1 N.	15.00	1 N.	11.0	1 N.	13.7	1 N.	21.0	.....	14.6	.....
Glyndon, 811	34	3.0	S.	W.	S.	.....	Good.	55	26.4	1 N.	14.8	1 N.	12.2	1 N.	.....	.....	.....	.....	.....	.....
Power's Fife No. 66	31	2.7	S.	W.	S.	92	Good.	55	.....	.....	21.23	1 N.	15.1	1 H.	15.8	1 N.	19.8	1 H.	12.6	.....
McKendrie's Fife	30	2.7	S.	W.	S.	92	Medium.	56	.....	.....	17.33	1 N.	12.9	1 H.	14.7	1 N.	19.8	.....	11.2	.....
Glyndon, 818	33	2.7	S.	W.	S.	90	Medium.	51	20.0	2 N.	13.9	2 N.	12.5	1 N.	.....	.....	17.8	1 N	8.8	.....
Wellman's Fife	....	....	S.	W.	S.	88	.....	.....	.....	.....	.....	.....	12.1	1 N.	15.2	1 N.	18.2	1 H.	10.6	.....
Haynes' Blue Stem	39	3.5	S.	W.	V.	91	Poor.	54	.....	.....	.....	.....	13.4	.....	13.5	....	13.6	.....	.....	.....

flowers on each spike or head. The anthers are then removed from these flowers and transferred inside the glumes of the other plant from which the stamens have been removed. All flowers which are so ripe that the anthers have opened are discarded and removed. The spike or head of wheat which has been treated or "handled" is then wrapped with a piece of paper to size of ordinary toilet paper which is tied with a string above and below the head. As a rule, only six to ten per cent of the flowers thus pollenized produce kernels. And we are not certain that each grain produced is in all cases a cross. Self-fertilization may, in rare cases, occur before the anthers are removed from the flower. But by this method many kernels can be produced with a small amount of labor, and upon trial the next year only the promising plants, or those showing the cross are retained.

Table LXXXIX. gives yields and other facts relative to the several varieties used as original stocks in originating new varities of wheat by crossing; also, by selecting. Others of our best varieties, having now been several times tested as to yield and quality, will serve as a basis from which to again start at selecting and crossing to make other improved kinds of wheat. This line of experimenting is not without its disappointments and difficulties, the time required to obtain results being long, but it promises very valuable results.

Breeding wheat is most interesting work, and a few general facts are here worthy of statement. The wheat flower is perfect, in that it has both male and female organs. These lie together in the nearly developed flower between the flowering glume and the palea. When the flower has nearly reached the stage when fertilization takes place the anthers, or male organs, which are small sacks filled with pollen grains, break open and the granular, globular pollen grains fall upon the feather-like female organ. These pollen grains germinate on the moist surface of the stigma, or female organ. The tube-like growth from the pollen grain penetrates the stigma and extending downward grows into the sack-like ovary in which the kernel of wheat is to be formed. Here the contents of the pollen tube unite with the female germ or ovule in the ovary, and by this union of the two sexual elements the new kernel is started into being. In reality a new wheat plant is generated by the union of these two elements. In nature the flower of wheat fertilizes itself. Henry de Vilmorin, the great French seedsman of Paris, says: "Not once in ten thousand cases does the grain of wheat result from the pollen being supplied by another flower from the same or another plant."

In originating a new kind of wheat by first finding a good variety, planting many selected kernels each a foot or so apart and then selecting from these plants the one that yields best, we make the one plant the single parent of an entire kind of wheat. This plant bears several hundred seeds, each of which has both as its male and as its female parent the same plant. When these seeds are planted each of these in turn has a common male and female parent, which in turn has as its male and female parent the original plant selected as the basis of the variety. In the third generation, likewise, each plant traces back to the original plant which was its only "great grandfather" and "great grandmother" combined in the one plant. The variety originated in this way is, in the stockbreeder's parlance, all of one "blood" with no "outcrosses," and "inbreeding" of the most "incestuous" kind here takes place. Objection has been raised to this way of originating wheat. The objectors assume that such pure inbreeding would result in weakness and that the wheat would soon "run out." But it must be remembered that in any variety of wheat this same inbreeding by self-fertilization is the constant method of generation. The only difference is, that, in the ordinary variety, there may be a large number of original plants from which all the grains have originating by self-fertilization. And should the wheat from some of these original "stocks" be larger or heavier in berry than from others, the careful use of the "screen" and "blast" in the fanning mill, or other seed wheat cleaning machine, would discard the poor and retain the good. This selection of seed in bulk might, and probably does, gradually make the variety better in size or weight of berry, and through these qualities might increase the yield of the variety. But the more rational way to select good original stock, it would seem, is to grow separately many individual plants, and choose those which have the greatest vigor and yield the most grain. The product of one grain can be increased to many bushels in a few years. The possibilities of improving the variety by the selection of seed wheat, oats, barley and rye, by means of the ordinary seed cleaning machine are overestimated by some. There are far greater possibilities in the selection of seed corn where nearly every stalk is the product of cross fertilization, and each grain on the stalk in turn is the product of the plant bearing the ear and serving as the female parent, and of some neighboring plant from which the male germ was carried by the air. Here each plant for many generations back has usually been the product of two not closely related

plants. Corn instead of having been closely inbred or self-fertilized is the product of cross-fertilization, and each grain on the stock is an example of what the stockbreeder would call "scrub breeding," little or no natural selection taking place. While corn plants usually lack in uniformity, the plants of a variety of wheat are generally very much alike in all botanical characters, varying however, in yield, as mentioned above. Very often a sample or field of wheat is composed of more than one variety, each with its distinct botanical characters. In this case there are no plants found with characters intermediate between the two kinds of wheat, thus showing that no crossing occurs. A small amount of blue stem wheat having been mixed with fife often results in a few years of careful selection over screens in the smaller fife seeds being screened out and the variety changed more and more to blue stem. This might occur in case of two varieties where the wheat having the larger kernels was really the smaller yielder and in other ways the least desirable of the two kinds. Likewise the larger or heavier kernels of wheat might be thus selected in annually cleaning the wheat and the yield of wheat not increased. If the large grains were selected by using the screen rather than the heavy ones by using the blast, the quality might even be made poorer. Yield per acre is a far more important consideration than either size of berry or hardness.

A New Seed Cleaning Machine was made out of an old implement. Separating the heaviest seeds of wheat or other seed grain is not always well accomplished by the fanning mill or by Beeman's Wheat Grader, or other machines which assort the grain mainly on the basis of the size of the kernels. In using the fanning mill considerable "wind" should be used that the blast may carry away all really light grains. Von Berg, a Russian, showed at the World's Fair a centrifugal machine for grading wheat. We imitated it almost exactly by using the Strowbridge Broadcast or "Shot-gun" Seeder. Instead of attaching it to the hind end gate of a lumber wagon box, it was set up in one corner of a large room in the barn. The belt running it from a sprocket wheel on the wagon wheel was left off and instead a hand crank was placed on the shaft. The crank was turned and the grain was allowed to run rapidly through the adjustable opening at the bottom of the grain hopper. This wheat, dropping on the rapidly revolving fans, was thrown across the room. That going farthest was found to be not only a few pounds heavier per bushel than that falling nearer the machine, but was practically clean of all trash and weed seeds. This machine as well as being

a better seed grader than a fanning mill was also a much more rapid means of cleaning and grading the seed grain. This machine is usually inferior to drills for seeding, but for preparing seed we know of nothing equal to it.

In Selecting Individual Plants to originate new varities of wheat it is to be proved whether the largest yielding plants will produce varieties which will be relatively large yielders, but by first testing each kind several times in variety field tests we need not distribute them until we are certain of their abilities to yield large crops.

The selection of plants to make new varieties did not stop with the first generation, but the plants grown from seeds of the best plants chosen the first year have been saved the second year, and the third season their crop was grown in quantities large enough to be placed in the variety field tests Likewise the ten best plants grown in the third year have been selected, the crop weighed and the best of these will be grown in quantity to put in the field test the fourth year.

Along with this continuous selection to secure new varieties we are conducting experiments to aid in the study of laws relating to heredity in grains and to learn the best means to use in improving cereals. We hope for rather more from a given amount of labor expended in the selection than in the crossing of varieties of grains, though the possibilities would seem rather greater from stocks'' first broken up in their blood lines by cross-breeding.

Crosses of various kinds of these wheats have been made, though the number which appear to be genuine crosses is not large. These crosses are being propagated and the best resulting plants selected from which to start varieties to be tested in field trials in the same manner as those above mentioned where crosses were not thus produced. These crossed wheats will differ from the others in an essential particular. In those simply selected because of large yields the plants are hermaphroditically inbred for many generations, possibly for many decades. In these the refreshing vigor supposed to rise from more or less "radical crossing" will be taken advantage of, if it is an advantage. In these crosses it is supposed that the inheritance of different blood lines will result, as we find is the case in animal crosses, in unusual variation. It will be the province of the experiments to determine which are the valuable variations or sports, and to perpetuate them. Finding some valuable sports should not be as difficult a task as we find it to be in breeding ani-

mals, because here we are able to deal at little expense with many individuals. Having found a plant, or generations arising from a plant, which had as its valuable variation the quality of producing under field conditions large crops, it would seem easy to perpetuate the variety and its good yielding habit. There is prevalent among farmers a belief that varieties or samples of cereal grains long grown under unfavorable conditions will run out, become of poor quality and unable to yield large crops. This is a subject worthy of extended experiment. Modern theories of heredity would cause one to presume that the inherited qualities of the self-fertilized plants would change only indeed very slowly. It would seem that a variety arising from a single plant and each plant propagating itself by self-fertilization, would be almost as changeless as the successive trees grafted from an original apple seedling, in which case division of the original plant and not sexual generation is the mode of propagation. So far as sexual generation is concerned, the original seedling apple tree, potato vine or geranium is the only individual, and the other trees, vines or shrubs are only its branches which have taken root and produced stems. The degeneration of varieties of potatoes twenty to forty years after their introduction as seedlings suggests that the life of the potato vine, propagated annually by means of its tubers (really branches), may, in that number of years, reach the period we call old age. It is thought by some that something may be accomplished by selection even in cuttings, as of the apple. The possibilities of taking advantage of variations in plants originating from self-fertilized flowers are certainly greater than is the case with cuttings. And in crosses between varieties like those we have made between fife and blue stem, so different that one has a smooth chaff while the other has chaff velvety with hairs, we expect marked variations. The testimony of other experiments is that a few generations of crossed wheats are required before the selection will result in uniform characteristics. By dealing with the individual plants we can discover in a very few years those which are the larger yielders and which "breed true to a type." So far our cross-bred wheats have accidentally been subjected to conditions giving the plants an unequal chance, and therefore only this general discussion is here attempted. The writer is especially anxious to enter into communication with all who have had experience in methods of crossing and the careful selection of cereal grains, clovers and grasses.

BARLEY—VARIETY TESTS.

With our lessened profits in wheat and special grain farming, more interest is centering in crops to be used as food for live stock. Barley which is not colored or slightly off odor or flavor from becoming wet from the time it ripens till it is marketed brings a very good price per acre in the markets for malting purposes. Experiments show that a ton of barley is nearly as valuable to feed most animals as a ton of corn. Owing to its liability to fer-

TABLE XC.—Barley, Variety Tests, 1894.

University Number.	Variety.	Source.	Height.	Botanical Notes.			Days Maturing.	Yield per Acre.		Grade.	Yield at Fargo, 1893.	
				Length of Spike.	Number of Rows.	Hull Holds Per cent.		Straw.	Grain.		Straw.	Grain.
1												
2	Manshury	Fargo	24	3.0	2	85	78	1,060	9.2	3		
3	Manshury	Fargo	21	2.5	6	85	71	1,060	13.3	4		
4	Salzer's	Fargo	20	3¼	2	85	78	620	12.1	3		
5	New Zealand	Fargo	21		2	85	83	790	8.5	4		
6	Manshury	Fargo	24	2½	6	85	71	910	14.3	4		
7	Champion of Vermont	Fargo	24	3.0	2	95	71	880	10.8	4		
8	Carter's	Fargo	20	3¼	2	85	78	910	8.2	4		
9	Imperial	Fargo	27	3.0	6	85	71	970	11.0	4		
10	Chevalier	Fargo	21	3.0	2	85	78	1,200	10 4	4		
11	Improved Black	Fargo	21	2.0	6	65	71	1,400	18.7	2		
12	Black Hulless	Fargo	24	1¾	6	65	71	970	19.3	1		
13	Excelsior	South Dakota	24	2½	6	80	71	970	15.2	3		
14	Chevalier	Brandon	21	3.0	2	85	78	1,190	12.7	4		
15	French Chevalier	Brandon	21	3¼	2	85	78	1,260	15.4	4		
16	Danish	Brandon	21	3.0	2	85	78	1,100	10.4	4		
17	Petschara	Brandon	27	2½	6	85	70	1,040	13.7	4		
18	Thanet	Brandon	21	3.0	2	85	78	1,230	11.8	4		
19	Oderbruck	Brandon	21	1¾	6	85	71	850	17.7	4		
20	Gold Thorpe	Brandon	21	3.0	2	85	84	860	5 0	4		
21	Odessa	Brandon	27	1¾	6	85	71	1,170	23.5	3		
22	Sharp's Improved	Brandon	24	3½	2	85	78	1,760	16.0	4		
23	Golden Grains	Brandon	21	3.0	2	85	78	1,600	14.5	4		
24	Manshury	Brandon	28	2½	6	85	71	1,560	21.6	4		
25	Canadian Thorpe	Brandon	21	3½	2	85	77	1,320	14.1	4		
26	Manshury	Brandon	28	2½	6	85	71	1,700	22.9	4		
27	Success or Beardless	South Dakota	21	1¾	6	85	71	780	19.1	3	1,016	24.58
28	Bernard's	Pipestone, Minn.	24	2½	6	85	71	1,600	20.8	4	1,242	20.73
29	Highland Chief	Station	21	1¾	6	65	77	1,200	12.5	4	1,305	17.77
30	Black	Station	21	1½	6	65	71	1,380	21.2	2	1,607	24.16
31	Oderbruck	Guelph	20				67		17.3			
32	Mandscheuse	Guelph	20				70		11.3			
33	French Chevalier	Guelph	20				78		1.8			
34	Imp. Chyne		21				78		4.1			
35	Thanet		21				78		6.9			
36	Scotch Improved	Guelph	21				66		17.7			
37	Empress	Guelph	22				78		1.8			
38	German Golden	Guelph	22				80		3.0			
39	Common Six Rowed		19				67		9.2			

ment the odor and flavor of the barley are often impaired and animals do not relish such injured barley as a large part of the food ration. All things considered, barley is one of the most important

crops we have. Sixty-nine samples, representing all the promising classes of barley, were secured from the North and South Dakota Experiment Stations, from the Dominion Experiment Farm at Brandon, Man., and from the Ontario Agricultural College, at Guelph, as shown in Table XC. We hope to find some of these kinds of barley which will be especially promising for propagating to distribute to farmers. We have placed the better kinds in our grain nursery to make improved kinds by selecting and crossing.

In 1894 thirty-nine varieties of barley were sown on the University Farm. At the University Farm the excessively wet spring made all our planting late, and the summer being very dry the crop was cut very short. Four varieties yielded over twenty bushels per acre, viz.: Odessa, 23.5 bushels; Manshury, av. 22.2 bushels: Black, 21.2 bushels; and Bernards, 20.8 bushels. Three yielded between eighteen and twenty bushels per acre, namely: Black Hulless, 19.3; Success, 19.1; and Improved Black, 18.7.

FLAX—VARIETY TESTS.

Tests of varieties of flax were commenced at the university farm and Coteau farm in 1894 with a view to discovering the best kinds to grow for seed, for seed and fibre combined, and for fibre alone. The droughty season made the trials somewhat unsatisfactory, especially the test of fibre production. Foreign seed obtained originally from the United States Department of Agriculture was tried, some from various seedsmen, and some selected from good crops grown by farmers. A few of these varieties were grown in 1893 at Fargo, N. D.

In Table XCI. are arranged the facts so far as we have tested the yields, the days required to mature, etc. Number 6 in Table XCI. certainly seems of enough promise as an especially good yielder of seed, and also of fibre, to justify us in propagating it and in using it for a basis in trying to make new varieties by selection and possibly by crossing. White blossomed Dutch flax is apparently not well adapted to use in our rather dry climate. Some years since much advice was given that we use flaxseed imported from Russia from which to grow fibres, or that which had been grown only one or two years in Western Europe, where it is the custom to get annually part of the seed from Riga and other parts of Russia. It seems quite wrong for us to depend on such a remote source for our flaxseed to grow fibre, even if Russia has a superior climate in which to produce flax seed. The figures in the accompanying ta-

ble indicate that the Northwest is quite as good a source of flax-seed for this country and possibly for the growers of flax fibre in Western Europe as is Russia. We find no records of efforts to improve flax by crossing plants, nor even by the selection of individual plants, and we shall endeavor to not only propagate the best seed we can find but also inaugurate experiments to improve flax by careful breeding.

TABLE XCI.—Flax, Variety Tests.

University No.	Variety.	Source.	Height.	Days Maturing at Coteau.	Days Maturing at University Farm	Yield.			Average of Two Yields.	Yielded at Fargo, 1893.	Average of Three Yields.
						Grain—Coteau.	Uni. Farm.				
							Straw.	Grain.			
1	Imported Belgian	U. S. Dept. of Agric'l'r.	21	70	64	3.9	1,182	6.7	5.3	.....	.....
2	Imp. White Blossom Dutch	U. S. Dept. of Agric'l'r	19	70	64	2.6	1,324	10.2	6.4	.....	...
3	Salzer's Dakota Grown	Fargo	19	70	64	4.4	1,485	6.9	5.7	14.4	8.6
4	Imported Riga	Fargo	21	70	64	2.5	1,709	8.3	5.4	10.0	6.9
5	American Flax	Badger State Seed Farm	21	.....	64	.....	1,831	10.9	.....	.....	.....
6	Fargo Flax	Fargo	18	70	64	4.8	1,812	9.1	7.0	16.1	10.0
7	Russian Flax	.....	18	.....	64	.....	1,606	8.5	.....	.....	.....
8	Imported Pure Riga	Fargo	20	70	64	2.8	1,855	9.1	6.0	.....	....
9	White Blossom Dutch	Fargo	17	70	64	2.1	1,045	11.5	6.8	12.4	8.7
10	*Belgian Riga	.....	19	.....	64	2.6	1,555	8.5	5.6	.....	.....
11	No. 1	University Farm	17	.....	64	.....	1,945	8.8	.....	.....	.. ...
12	No. 2	University Farm	22	.....	64	.....	1,724	9.0	.....	....	.....
13	No. 3	University Farm	22	.....	64	.....	1,888	8.5	.....	.....	.....
14	Belgian Flax	N. B. & G. Co	18	70	.....	2.4	.....	.....	.....	.....	.....
15	Belgian Flax	N. B. & G. Co	18	70	.....	2.6	.....	.....	.....	.....	.....

*Grown in Flanders, 1891.

PEAS, FIELD—VARIETY TESTS.

During several years past we have been testing varieties of field peas and studying the best ways of planting them and have devised a better means of harvesting the ripe peas.

Table XCII. gives the yields of the varieties planted at the university farm. Owing to drought, making the crop light, and to a high wind which blew the harvested peas about, thus mixing those on adjacent plots, records of yields at the Coteau farm were not made. The small white field peas, the somewhat larger white field peas, as Prince of Wales, Blue and Green field peas, and both white and black eyed marrowfats, as offered by our seedsmen, are nearly always fair yielders. In this table are a number of the best varieties we used in variety tests during the past years. They are marked as coming from the university farm and Fargo, and with them are a number of varieties found best after several years' trial at the Canadian Experiment Farm at Brandon, Man. These were kindly furnished us by Supt. S. A. Bedford. The yields in

1894 have been very low for all kinds, and are reported here to show which kinds yield best under very droughty conditions. The yields of the varieties grown by me in 1892 and 1893 are given, showing how these varieties yielded on a heavy soil in the wet season of 1893 at Fargo, N. D., and their average yields in 1892 at Power, Richland county, on sandy soil, with a fairly good supply of rain and on good soil with a fair supply of rain at Michigan City, Nelson county, N. D. While peas yield poorly at times, our experiments with them indicate as good average yields per acre on our wheat soils as we obtain of wheat.

TABLE XCII.—Peas, Variety Tests.

University No.	Variety.	Source.	Size of Peas.	Form of Ripe Peas.	Color of Ripe Peas.	Days Maturing.	Length of Vine.	Evenness of Ripening.	Yield at University Farm.	Yield, 1893, at Fargo.	Yield, 1892, Dak. Av. of two Local.
1	Mummy	Brandon				70	18	90	2.7		
2	Multiplier	Brandon				71	20	85	3.3		
3	Crown	Brandon				67	20	90			
4	Prussian Blue	Brandon				71	19	90	4.5		
5	Centennial	Brandon				70	19	85	4.2		
6	Pride	Brandon				65	15	90	4.3		
7	White Canada Field	Brandon				65	25	85	2.7		
8	White Eyed Marrowfat	University Farm	Medium	Smooth.	White.	73	26	90	3.2		
9	White Canada Field	University Farm	Medium	Smooth.	White.	68	16	90	6.5		
10	Black Eyed Marrowfat	University Farm	Small.	Smooth.	White.	7	20	85	9.8		
11	Prince of Wales	University Farm	Large.	Wrink.	White.	70	15	90	4.3		
12	Blue Imperial	University Farm	Large.	Smooth.	Blue.	69	20	90	6.2		
13	Golden Vine	Fargo	Medium	Smooth.	White.	71	24	75	4.2	20.9	41.2
14	Black-Eyed Marrowfat	Fargo	Large.	Smooth.	White.	70	25	75	5.2	17.3	33.6
15	Alpha	Fargo	Medium	Smooth.	Blue.	70	13	90	8.6		
16	Bliss' Evergreen	Fargo	Large.	Wrink.	Blue.	70	14	85	8.2	16.1	20.2
17	Horsford's Market Garden	Fargo	Medium	Wrink.	Blue.	66	13	85	5.7	12.9	30.0
18	Yorkshire Hero	Fargo	Large.	Wrink.	White.	71	20	85	5.3	14.3	27.7
19	Blue Prussian	Fargo	Medium	Smooth.	Blue.	73	20	85	4.3	10.9	40.1
20	Egyptian Mummy	Fargo	Medium	Smooth.	White.	71	20	90	7.7	11.9	34.6
21	Crown	Fargo	Small.	Smooth.	Blue	68	15	75	7.9	13.7	41.0
22	Golden Vine	Fargo	Small.	Smooth.	White.	71	23	75	5.7	13.7	33.0
23	White Canada Field	Fargo	Small.	Smooth.	White.	67	19	90	9.2		
24	Prince of Wales	Fargo	Large.	Wrink.	White.	65	18	90	9.2	16.5	45.8
25	Pride of the Market	Fargo	Large.	Wrink.	Blue.	66	19	85	8.2	15.9	25.2
26	Green Canada Field	Fargo	Medium	Smooth.	Blue.	70	25	90	7.8	10.0	
27	Blue Field	Fargo	Medium	Smooth.	Blue.	78	25	90	8.3	21.1	
28	Audubon	Audubon	Medium	Smooth.	Blue.	78	24	90	7.0		
29	Potter	Brandon				78	23	90	6.7		
30	Canadian Beauty	Brandon	Large.	Smooth.	White.	78	29	90	9.7		
31	Prince Albert	Brandon	Medium	Smooth.	White.	78	24	85	6.6		

MILLET—VARIETY TESTS.

A collection of varieties of millets was made in the spring of 1894, and plots of each were planted at the university farm and at the Coteau farm. At the university farm the drought prevented us getting any results, the seed not even germinating. Table XCIII. shows the yields of several varieties at the Coteau farm. Under the rather droughty conditions prevailing there the past season it will

be observed that one of the smaller varieties of millet yielded the most hay. By an unintentional planting of Dhoura with the millets we were fortunate enough to give this non saccharine sorghum a trial with millets as a hay producer. It may even prove useful as an annual pasture crop, something often needed in cases where a crop of grass for pasture has failed to make a stand. California or broom corn millet yielded only about as much as the average millets. This so-called millet, however, is of great interest. It is not a true millet, but belongs to the genus panicum (Panicum mileacerum) rather than to Setaria. The argument strongly presented against millet as a food for horses, on account of its active effect on the kidneys, will doubtless not be held against this panicum milleaceum. It bears heavily of seed, and under some conditions may prove profitable as a grain crop to raise for seed. More favorable seasons will tell us more definitely of the value of these two promising new annual fodder plants.

TABLE XCIII.—Millet, Variety Tests, 1894.

	Variety.	Yield of Hay per Acre at Coteau Farm.
1	Hungarian Grass	4,820
2	German Millet	2,190
3	California Millet	3,360
4	German Millet	3,031
5	White French	3,000
6	Dhoura, or Large African	2,580
7	Salzer's Dakota Grown	3,490

WHEAT AND OATS MIXED, SUCCOTASH.

In 1891 a study was begun of the economy of sowing wheat and oats together. Nine plots forty-five rods by less than two rods were sown to wheat, to oats, and to wheat and oats mixed in several proportions on corn stubble. The grain was all cultivated in with a corn cultivator and the land made smooth by using the Scotch harrow. The conditions were good for a large crop. The land is naturally well underdrained, and having been in clover prior to raising a crop of corn, it was in good heart. In places the land was so rich that the oats lodged quite badly. The amount of lodging on each plot, as also the yield of each kind of grain and of the straw is shown below.

By accident the proportions of wheat and oats in the succotash crop were not preserved.

TABLE XCIV.—Succotash of Wheat and Oats Mixed.

Plot.	Amount Seed Sown.	Per Cent Straw Lodged.	Pounds Grain per Acre.	Bushels Wheat per Acre.	Bushels Oats per Acre.
1	Oats, 3⅓ bushels per acre	5	3,109	.....	97
2	Oats, 2½ bushels, and wheat, ½ bushel per acre	3	3,196	.....	.....
3	Wheat, 1⅓ bushels per acre	None.	2,463	41.0	.....
4	Oats, 2¼ bushels; wheat, ¾ bushel per acre	15	3,060	.....	.....
5	Oats, 3 bushels per acre	33	3,001	.....	94
6	Oats, 1 5 9 bushels; wheat, 7 9 bushel per acre	33	2,697	.....	.....
7	Wheat, ½ bushel per acre	3	2,199	36.6	.....
8	Oats, ¾ bushel; wheat, ¾ bushel per acre	2	2,654	.....	.....
9	Oats, 3 bushels per acre	25	2,632	.....	82¼
.....	Average of wheat alone	.....	2,331	38.8	.....
.....	Average of oats alone	.....	2,914	.....	91
.....	Average of succotash	.....	2,902	.....	.....

As the wheat is but little more valuable for feed than oats the advantage of the mixed crop over oats in this single case is very small. Not much would be gained in this case by separating them by means of an "angle mill," made to separate oats from wheat.

METHODS OF SEEDING OATS.

In 1891 ten plots, each forty-five rods long and containing nearly one-half acre were sown to oats, of the Welcome class, to test three methods of seeding. The land had been in corn the year previous, was naturally well underdrained and was in good heart. The corn stalks had all been removed, and the seed was sown with

TABLE XCV.—Manner of Covering Oats Sowed Broadcast.

Plot.	Manner of Seeding on Corn Stubble.	Oats, per Acre, Bushels.	Straw per Acre, Pounds.
1	Cultivated in with corn cultivator	82	3,107
2	Harrowed in on spring plowed land	85	3,499
3	Plowed under four inches deep with cross plow	82	3,510
4	Same as No. 1	82	3,369
5	Same as No. 2	81	3,895
6	Same as No. 3	89	3,781
7	Same as No. 1	92	3,727
8	Same as No. 2	72	2,936
9	Same as No. 3	83	3,575
10	ame as No. 1	74	3,152
.....	Average of plots "cultivated in"	82½	3,336
.....	Average of plots sowed on top of spring plowing	79⅔	3,443
.....	Average of plots plowed under	84⅔	3,622

a broadcast seeder, each plot having four seeder widths. Nos. 1, 4, 7 and 10 were sown in the unprepared corn stubble land and were "cultivated in" with an ordinary two-horse corn cultivator, followed by the Scotch harrow. Nos. 2, 5 and 8 were first plowed and the oats sowed on the spring plowing, and "harrowed in." On Nos. 3, 6 and 9 the oats were sown on the corn stubble and plowed under three or four inches deep with a stirring plow, the land being smoothed over with the harrow. The table gives the manner of seeding and the yield of straw and grain.

The results are surprisingly uniform. The conditions were good for a large crop of oats. Doubtless had the season been unfavorable one or two of the methods would have been found best.

ROLLING OATS TO PREVENT LODGING.

In 1891 a field of oats, which had been seeded in a uniform manner, by sowing the seeds on corn stubble and cultivating it under with a corn cultivator and then smoothing with the drag, was

TABLE XCVI.—Rolling Oats to Prevent Lodging.

Plot.		Bushels Oats per Acre.	Pounds Straw per Acre.
1	Rolled twelve inches high	84	2,573
2	Not rolled	85	3,013
3	Rolled when eight inches high	76	2,706
4	Not rolled	81½	3,147
5	Rolled when twelve inches high	75	2,280
6	Not rolled	73½	2,880
7	Rolled when eight inches high	62	2,440
.....	Average of plots not rolled	80	3,013
.....	Average of plots rolled when eight inches high	69	2,573
.....	Average of plots rolled when twelve inches high	79½	2,427

divided into seven plots each two by thirty rods. On plots 1 and 5 the oats were rolled down with a two-horse roller of medium weight when the plants stood twelve inches high. On plots 3 and 7 the oats were rolled down when eight inches high. And plots 2, 4 and 6 were not rolled, but served as check or control plots to compare with those on which the roller was used, to test whether rolling would prevent lodging and cause a better yield of oats.

The oats which were subjected to pressure by the roller did not ripen as soon within about two days as those undisturbed. The land was quite rich and the oats on all the plots went down in spots.

The oats rolled when eight inches high stood up somewhat better than those not rolled or those rolled when 12 inches high. The oats on all rolled plots were not so tall by a few inches as those not rolled and the yield of straw as well as of grain was lessened by rolling.

TABLE XCVII.—Hay of Mixed Annual Crops.

Oats and Peas Mixed for Hay.

No. of Plot.	Grain.	Purpose.	Days Maturing for Hay.	Weight of Hay Per Acre.
1	Oats, 80 pounds	Hay	69	2,130
2	Oats, 64 pounds	Hay	69	2,270
3	Oats, 56 pounds; peas, 30 pounds		69	1,890
4	Oats, 50 pounds; peas, 30 pounds		69	1,960
5	Peas, 180 pounds		69	1,470
6	Peas, 120 pounds		69	1,480

Flax and Millet Mixed for Hay.

No. of Plot.	Grains Sown.	Days Maturing for Hay.	Yield Hay per Acre.
1	Flax, 25 pounds; millet, 25 pounds	42	440
2	Flax, 18 pounds; millet, 25 pounds	42	370
3	Flax, 25 pounds; millet, 15 pounds	42	430

Peas and Flax for Hay.

No. of Plot.	Grain per Acre.	Days Maturing for Hay.	Yield of Hay per Acre.
1	Peas, 1½ bushels; flax, 1 peck	57	760
2	Peas, 2 bushels; flax, 1 peck	57	820
3	Peas, 1½ bushels; flax, 1 peck	52	790
4	Peas, 2 bushels; flax, 1 peck	52	600
5	Peas, 1½ bushels; flax, 1 peck	48	340
6	Peas, 2 bushels; flax, 1 peck	48	740

HAY PRODUCTION BY SEEDING ANNUAL CROPS.

In 1894 millet, oats, peas and flax were each sown alone, and they were also mixed in various combinations and in different proportions to find how best to make crops of hay by the use of annual forage crops. The land chosen at the university farm is gravelly and with the severe drought no crop resulted. At the Coteau farm, however, some of the plots did fairly well, though drought there also did considerable injury. The oats, and the oats and peas in combination, produced most, while the other crops produced very poorly. Certainly for very droughty conditions none of these crops promise large yields of hay. We have started experiments also in the growing of pasturage, as well as soilage crops for midsummer feeding by the use of annual forage crops.

GRAIN SEEDING IMPLEMENT TESTS—TIME OF PLANTING.

WHEAT.

In the spring of 1894 on the university farm seven plots were sown to wheat and a like number to oats, two with shoe drill, two with chain drill, two with hoe drill, two with broadcast seeder and one with press drill. One of each of the pairs was sown medium early, on April 23d, and one on May 4th, rather late in the season. Early seeding of still other plots with each machine was prevented by constant light showers which kept the land muddy. The soil was a rich clay loam, fall plowed and in good condition. In the early seeding of wheat there was little difference, the several machines ranking in the following order: hoe drill, press drill, Dowagiac shoe chain drill and broadcast seeder. The extremely dry season caused a very short yield of grain. In the later planting the press drill, unfortunately, was not used. The chain drill plot yielded 8.1 bushels, the hoe drill plot yielded 7.2 bushels, and the broadcast seeder plot gave a yield of only 5.5 bushels per acre.

In straw, the yields in the early planted plots were equally large where the press and hoe drills were used, and six per cent less where the wheat was seeded with the chain shoe drill and the broadcast machine. In the later planting, the hoe drill gave the largest yield of straw and the broadcast seeding the smallest amount of straw per acre.

OATS.

In the earlier seeding to oats there was the largest yield on the plots sown with the hoe drill, the shoe chain drill stood next, the broadcast seeder next and the press drill last. In the later

seeding the hoe drill is again decidedly in the lead, the shoe drill next and the broadcast decidedly the lowest in yield.

In the yields of straw the implements rank, for the earlier planting, as follows: hoe drill, press drill, shoe chain drill and broadcast seeder; and for the late planting thus: hoe drill, shoe chain drill, and broadcast seeder. In Table XCVIII. are collected the results of an experiment in 1893 and a similar trial in 1894.

TABLE XCVIII.—Wheat Implements for Sowing, Time of Sowing.

No. of Plot.	Implement.	Date Sown.	Amount Seed per Acre.	Days Maturing.	Per cent Stand.	Yield per Acre.		Average of Each Machine for Both Dates.		Yield, 1893.		Average for two years.	
						Pounds Straw.	Bushels Grain.	Pounds Straw.	Bushels Grain.	Pounds Straw.	Bushels Grain.	Pounds Straw.	Bushels Grain.
1	Havana drill	Apr. 23...	1.5	85	85	1,780	10.3	1,780	10.3	.....	.....	.....	.....
3	Dowagiac shoe-chain drill..	Apr. 23...	1.1	86	75	1,692	10.2	1,477	9.1	.....	.....	.....	.....
4	Dowagiac shoe-chain drill..	May 4....	1.5	81	82	1,262	8.1						
5	Hoe drill	Apr. 23...	1.4	86	80	1,781	10.7	1,572	8.9	1,362	13.35	1,467	11.12
6	Hoe drill	May 4....	1.3	81	82	1,364	7.2						
7	Broadcast seeder	Apr. 23...	1.7	86	78	1,700	10.0	1,316	7.7	1,575	15.56	1,445	11.63
8	Broadcast seeder	May 4....	1.3	81	75	932	5.5						
...	Average of all machines	Apr. 23...	.....	86	.....	1,738	10.3	.....	.....	.....	.....	.....	.....
...	for each date	May 4....	.....	82	.....	1,090	6.2	.....	.....	.....	.....	.....	.....
	Oats.—Implements for Sowing—Time of Sowing.												
1	Havana drill	Apr. 23...	2.2	86	90	1,634	29.1	1,634	29.1	.....	.....	.....	.....
2	North Star seeder	May 4....	1.6	82	82	1,103	26.7	1,103	26.7	3,278	61.03	2,190	43.86
3	Dowagiac shoe-chain drill..	Apr. 23...	2.5	86	88	1,631	32.8	1,454	31.3	.....	.....	.....	.....
4	Dowagiac shoe-chain drill..	May 4....	2.3	82	80	1,277	29.8						
5	Hoe drill	Apr. 23...	2.0	86	85	1,795	34.5	1,562	37.1	3,085	57.46	2,323	47.28
6	Hoe drill	May 4....	1.6	81	82	1,330	39.7						
7	Broadcast seeder	Apr. 23...	2.4	86	82	1,361	32.2	1,225	27.9	3,221	61.25	2,223	44.57
8	Broadcast seeder	May 4....	1.4	82	78	1,090	23.7						
...	Average of all machines	Apr. 23...	.....	86	.....	1,605	32.1	.....	.....	.....	.....	.....	.....
...	for each date	May 4....	.....	81	.....	1,200	30.0	.....	.....	.....	.....	.....	.....

During the past several years a number of experiments have been conducted in Minnesota and by other experiment stations in the Northwest, under conditions more or less droughty, to test the different ways and machines for sowing spring grains. An immense amount of experimenting, some of it very costly, has also been done by the farmers and by manufacturers of wheat seeding machinery. The broadcast seeder was largely supplanted a decade or more ago by the hoe drill, and now shoe drills have nearly supplanted the hoe drills in the Northwest.

Broadcast seeders of several patterns are still in use by some and on heavy moist soils, and especially for very early sown they are very useful. The labor of seeding is least when the broadcast machine is used. On soils like much of that in the Red River Valley no harm seems to come from "mudding" in the grain, as there

the puddled soil when dry "slacks" into dust as would chunks of quick lime. By using the broadcast machine earlier than it is possible to use the drill because of rains and muddy soils early in spring, Red River Valley farmers sometimes get their crops planted early and have a better crop than if they wait until the soil is dry enough to use the drill. Where the soil has not that peculiar property of again breaking up into fine particles when dried after puddling, this use of the broadcast seeder followed by the drag is not advisable. Broadcasting seems to be as good a plan of seeding as any when there is an abundance of moisture in the surface of the soil. When the soil is rather dry the drill is better than the broadcast seeder. The class of drills known as hoe drills, which have shovels attached to the bottom of a tube through which the seeds fall into the furrow just behind the point of the small shovel are excellent for some conditions. In seeding among corn stalks they work better than "shoe" drills, as the shoes or runners cannot cut through the tough stalks. Where the stubble land is fall plowed, so that the stubble of corn or small grain is turned under, the shoe drill is preferable. These drills are provided with shoes or runners fashioned like those used on two-horse corn planters and are of various sizes. The four-horse machine has sixteen and twenty-two shoes six to nine inches apart.

There are two general classes of shoe drills, those with a press wheel following each shoe and those without. A chain is hung so as to drag after the shoe on some of the best drills which have no press wheel. Several kinds of these press shoe and chain drills are proving very useful. The form of shoe found best is what is known as the V shaped shoe. The shoes which have a broad base and opening dropping the seeds in the bottom of the furrow nearly an inch wide are found to work badly in muddy soil. By so shaping the heel of the shoe that the bottom of the furrow is V shaped the shoe does not clog up with soft mud. In heavy lands the farmers will find the chain shoe drill most satisfactory, while on droughty lands, especially in the southwestern part of the state, where the rainfall is least, the press shoe drill is best. Grass seeding attachments can be procured with nearly or quite all grain drills.

OATS—THICKNESS OF SEEDING—TIME OF SOWING.

In 1894 twelve plots of oats were sowed to determine the amount of seed that should be used per acre and the best time of seeding, with a view to getting results through a number of years on these

two practical questions. Table XCIX. shows that two and one-fourth bushels of seed per acre resulted in the largest yield of grain and two and three-fourths bushels of seed gave the largest yield of straw. The average yield of the six plots sowed April 25th was a bushel more per acre than on the six plots sowed twelve days later. The yield of straw was also larger with the earlier seeding. The oats sowed April 25th ripened five or six days earlier than those which had been sowed twelve days later.

TABLE XCIX.—Oats, Amount Seed per Acre and Time of Sowing.

No. of Plot.	Date Sown.	Amount Seed per Acre.	Days Maturing.	Yield per Acre.		Average.	
				Straw.	Grain.	Straw.	Grain.
1	April 25	1½ bushels	89	1,320	32.2	1,260	31.7
2	May 7	1½ bushels	80	1,200	31.2		
3	April 25	1¾ bushels	86	1,180	33.4	1,265	35.4
4	May 7	1¾ bushels	80	1,350	37.5		
5	April 25	2 bushels	86	1,605	46.8	1,452	39.8
6	May 7	2 bushels	80	1,300	32.8		
7	April 25	2¼ bushels	86	1,600	43.4	1,427	44.2
8	May 7	2¼ bushels	80	1,255	45.1		
9	April 25	2½ bushels	86	1,555	40.5	1,519	41.1
10	May 7	2½ bushels	80	1,480	41.8		
11	April 25	2¾ bushels	86	1,720	40.0	1,545	40.7
12	May 7	2¾ bushels	80	1,370	41.5		
	Average yield { April 25		86½			1,496	39.4
	Average yield { May 7		80			1,326	38.3

WHEAT, OATS, BARLEY AND FLAX—TIME AND DEPTH OF PLANTING.

An experiment was started in 1894 to determine the depth at which wheat, oats, barley and flax should be planted and the time at which the planting should be done. One plot was sown early and another later at each of the following named depths: Three-fourths, one and one-half, two and one-half and three and one-half inches.

In Table C. are collected the facts as to depth and time of seeding and the yields. All were on rich open clay soil, fall plowed and fairly compact, but in fine tilth. To get at general laws for our state, and for its different soils and climatic conditions, these trials need repeating at other times here and at other places. Many light rains in early spring caused all our planting to be rather late. The drought made all yields very small. The wheat planted three and one-half inches deep yielded best in grain, while that planted three-fourths inch deep yielded much the larger amount of straw.

The yield of wheat was larger with the greater depths, while in case of the straw directly the opposite is true. The four plots of wheat sown April 27th yielded four and one-half bushels more grain and 650 pounds, or one-half more, straw per acre than did the four plots sown ten days later. Wheat planted May 7th ripened two days later than that which had been planted ten days earlier.

The oats planted one and one-half to two and one-half inches deep yielded the best in grain. Those planted one and one-half inches deep yielded the most straw and those planted only three-fourths inch deep gave the next best yield, while that planted

TABLE C.—Grains, Time of Planting, Depth of Planting.

No. of Plot.	Kinds of Grain.	Date Sown.	Depth Sown.	Days Maturing.	Per Cent. Stand.	Yield per acre.		Av. Yield per Acre.	
						Straw.	Grain.	Straw.	Grain.
1	Wheat	April 27	¾ inch	88	80	3,155	20.8	2,207	20.4
2	Wheat	May 7	¾ inch	81	80	1,260	20.0		
3	Wheat	April 27	1½ inches	88	82	1,700	21.9	1,440	20.6
4	Wheat	May 7	1½ inches	81	82	1,180	19.4		
5	Wheat	April 27	2½ inches	89	80	1,460	23.1	1,265	21.4
6	Wheat	May 7	2½ inches	81	80	1,070	19.7		
7	Wheat	April 27	3½ inches	90	78	1,130	30.3	1,200	25.0
8	Wheat	May 7	3½ inches	81	80	1,270	19.7		
	Average yield	April 27		89				1,841	24.1
		May 7		81				1,187	19.7
9	Oats	April 27	¾ inch	87	80	2,010	43.4	1,775	38.1
10	Oats	May 7	¾ inch	81	80	1,540	32.8		
11	Oats	April 27	1½ inches	87	82	2,790	44.1	2,215	40.1
12	Oats	May 7	1½ inches	81	82	1,640	36.2		
13	Oats	April 27	2½ inches	87	82	1,700	46.8	1,670	39.9
14	Oats	May 7	2½ inches	81	82	1,640	33.1		
15	Oats	April 27	3½ inches	87	82	1,640	42.5	1,590	37.8
16	Oats	May 7	3½ inches	81	80	1,540	33.1		
	Average yield	April 27		87				2,045	44.2
		May 7		81				1,590	33.8
17	Barley	April 27	¾ inch	80	83	2,120	24.5	1,730	23.3
18	Barley	May 7	¾ inch	71	82	1,340	22.1		
19	Barley	April 27	1½ inches	80	88	1,080	23.3	1,410	24.8
20	Barley	May 7	1½ inches	71	80	1,740	26.3		
21	Barley	April 27	2½ inches	80	85	1,500	22.9	1,450	25.0
22	Barley	May 7	2½ inches	71	75	1,400	27.1		
23	Barley	April 27	3½ inches	80	85	1,770	31.9	1,555	29.1
24	Barley	May 7	3½ inches	71	75	1,340	26.3		
	Average yield	April 27		80				1,670	25.7
		May 7		71				1,455	25.4
25	Flax	April 27	¾ inch	88	85	1,600	10.7	1,285	9.1
26	Flax	May 7	¾ inch	78	80	970	7.6		
27	Flax	April 27	1½ inches	88	85	1,380	11.1	1,125	9.3
28	Flax	May 7	1½ inches	78	80	870	7.6		
29	Flax	April 27	2½ inches	88	85	1,250	9.8	1,115	8.8
30	Flax	May 7	2½ inches	78	75	960	7.8		
31	Flax	April 27	3½ inches	88	80	1,270	9.6	1,185	8.3
32	Flax	May 7	3½ inches	78	75	1,100	7.1		
	Average yield	April 27		83				1,375	10.3
		May 7		78				975	7.5

three and one-half inches deep yielded least of both grain and straw. The average of the four plots planted April 27th is 44.2 bushels per acre, while the average of the corresponding four plots planted ten days later is 10.4 bushels less. The straw on the earlier planted plots is nearly one-third more per acre than on the plots planted later. Oats planted May 7th ripened four days later than that which had been planted ten days earlier.

The barley planted three and one-half inches deep gave decidedly the best yield of grain, while that planted shallower gave the largest crop of straw. The yield of grain was practically the same on the plots planted May 7th as on those planted ten days earlier, but the early planted plots yielded the most straw. Barley planted May 7th ripened only one day earlier than that which had been planted ten days earlier.

The flax yielded best in grain and straw where planted shallow. The flax planted April 27th yielded decidedly better both in grain and in straw than that planted ten days later. Flax planted May 7th ripened on the same day as that which had been planted ten days earlier.

Earlier planting produced better yields than later in fourteen out of sixteen pairs of plots compared, the two exceptions being two of the four pairs of barley plots.

FIELD MANAGEMENT AND ROTATION OF CROPS.

In our older counties the pioneer lack of system in field management has been replaced. Instead of the constant cropping to wheat, found to no longer pay, farmers now grow a variety of crops. But there is a great lack of definite knowledge of the relative net profits from each crop, counting labor and land at cost. We know little of the relative net profits from any rotation of crops. We have no definite knowledge of the condition in which one crop leaves the land for each other crop. And other questions of vital importance in getting profits out of our fields have not as yet been worked out by careful experiments. A study of field management, to have much value, must be done in a comprehensive manner. The various staple crops must be grown in numerous combinations. A few years will not suffice, but each cycle of all rotations used in the experiment should be repeated a few times. Since the state is composed of sections widely differing as to soil and climate, the management of fields must differ in the several parts. Some of the simpler standard rotations should be tried in the several sections of the state, and others adapted to the peculiar conditions of

the respective localities should also be carried out in comparison. This way of studying the questions of how to manage fields is being recognized in other states. We are not necessarily interested in how much a field will produce of any crop, but how much of net profit there is for the owner. The same is true of a rotation running through a series of years. We want that combination of crops in the rotation with which the farmer can make the most money and leave his land in good condition. There are many other problems in field management aside from the question of what crops shall enter the rotation. We want to know how deep to plow in the fall and in spring on each kind of soil for each crop. And we want spring and fall plowing compared. How to treat the furrow slice that it will reconnect its capillary forces with the subsoil is of importance. And how to manage the upper few inches of the furrow slice that it will act as a mulch to conserve the moisture in the soil is a problem of much interest. The relative merits of the different ways of seeding grains need to be tested. The best time for seeding each kind of grain and the depth at which the seed should be placed are not clearly known for each condition of soil and climate. The economy or loss in burning stubble of small grains has not been made clear by scientific demonstration. We are comparatively ignorant as to when and how to use the harrow on newly planted small grains. And the experiments along the line of intercultural, or summer tillage have by no means exhausted that subject. New ways of using old crops and the introduction of new crops, as yet but little tried, offer a large field for study and practical trial. Methods of harvesting and curing crops and their preservation forms a most important part in careful field management. The policy of turning the larger part of field crops into live stock products and returning the carefully husbanded manure to the soil which bore the crop has a vital relation to making the field management continuously successful. The crops to which it is best to apply manure, the manner of preparing and applying it and the amount per acre to use are more questions regarding which our farmers are not fully informed. Ere many years land plaster will have been found useful on some of our soils for certain crops, and we will see the wisdom of purchasing the slaughter house fertilizers, now shipped out of our state to enrich other commonwealths. Experiments on the value of manure and how to make profits by using it will cause our farmers and gardeners to place a higher value on the great amounts of fertility now being

wasted in our barnyard manure heaps and in heaps of manure thrown out of our cities and towns. Only by careful experiments can we learn which crops are best to grow for green manure, and we require actual figures to emphasize the value of these crops. The management of fields, so as to destroy and keep in subjection weeds, is a phase of the problem worthy of much study. How to make the field conditions unsuited to injurious insects, and even to lessen the injury from plant diseases, brings up questions of vital importance. Only a part that we should know regarding grasses and clovers for pastures and meadows and annual plants for forage crops has been learned from the practical experience of farmers or by experimenters. Practical experience regarding these crops is dearly bought, and the experimenter finds that gathering practical facts goes slow and at the expense of a large amount of experimenting.

Some of these questions require only a few experiments running through a few years. Others require not only many trials but that the experiments shall be carried on for a long time and under varied conditions. To settle most of the questions mentioned above would give us data with which to begin the creation of farm book-keeping, or a system of accounts adapted to our keeping track of farm business. Comparatively few of these questions can be taken up in the near future, as a few things well done have far more value than many things only poorly started.

ROTATION OF CROPS.

The divisions of Agriculture and Agricultural Chemistry have undertaken the joint study of rotations of crops.

In the spring of 1894 forty-four plots each two by eight rods, one-tenth acre, were laid off on fairly uniform land on the northeast corner of the university farm. The land is a medium heavy clay loam or slightly modified till soil of good fertility, naturally well underdrained and able to retain a large amount of capillary moisture through periods of severe drought. The plots are in four series running east and west and containing eleven plots each, these running north and south. Between each series the ends of the plots are separated by alleys a rod wide, and between each pair of plots are alleys twelve feet wide, an alley two feet wide separating the two plots of the pair. This separates the plots and enables the teamster to reach all plots in using any machine without unnecessary tramping.

The land on which these plots were laid out had grown barley in 1893, oats in 1892 and had been in clover and timothy meadow

Series.	Plot.	1894	1895.	18	Rotation for Each Plot.
I	1	Wheat	Wheat	*Tim. a	Wheat 1 yr., meadow 2, oats 1, (manure 8 tons per acre) corn 1*a*.
	2	Wheat	Wheat	Bro	Wheat 1, bromus 1 or more, oats 1, corn 1 *a*.
	3	Wheat	Wheat	Tim	Wheat 1, timothy 2, oats 1, corn 1 *a*.
	4	Wheat	Wheat	Clo	Wheat 1, clover 1 or 2, oats 1, corn 1 *a*.
	5	Wheat	Wheat	*Clo. a	Wheat 1, meadow 2, oats 1, millet 1 *a*.
	6	Wheat	Wheat	*Clo. a	ontrol plot, same as No. 1, Series I.
	7	Wheat	Wheat	*Clo. a	heat 1, meadow 2, oats 1, mangles 1 *a*.
	8	Wheat	Wheat	*Clo. a	heat 1, meadow 2, oats 1, rape 1 *a*.
	9	Wheat	Wheat	*Clo. a	heat 1, meadow 2, oats 1, potatoes 1 *a*.
	10	Wheat	Wheat	*Clo. a	heat 1, meadow 2, oats 1, sunflower 1 *a*
	11	Wheat	Wheat	*Clo. a	ntrol plot, same as No. 1, Series I.
II	1	Wheat	Wheat	*Clo.	ntrol plot, same as No. 1, Series I.
	2	Corn	Peas *b*	B	rn 1, peas 1, barley 1, clover 1.
	3	Barley	Oats	Ti	rley 1, oats 1, timothy 2.
	4	Barley	Oats	Ti	ley 1, oats 1, timothy 2 *y*.
	5	Millet	Barley		let 1, barley 1, corn 1, oats 1.
	6	Wheat	Wheat	*Clo.	trol plot, same as No. 1, Series I.
	7	Corn	Corn		n in hills continuously.
	8	Potatoes	Potatoes	P	toes continuously.
	9	Mangles	Mangles	M	gles continuously.
	10	Peas *e*	Peas		, field, in drills, continuously.
	11	Wheat	Wheat	*Clo.	rol plot, same as No. 1, Series I.

*Timothy 8 lbs., red clover 6 lbs. *a* Eight to
peas thickly in drills 30 inches apart. *y* Top
day. *d* Dent corn, hills in ordinary way. *e* Plant field

TABLE CI.—Statement Showing Experiments in Rotation of Crops.

Series.	Plot.	1894	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Rotation for Each Plot.
I	1	Wheat	Wheat	*Tim. and Clo.	Meadow	Oats	Corn *a*	Wheat	Meadow	Meadow	Wheat 1 yr., meadow 2, oats 1, (manure 8 tons per acre) corn 1*a*.
	2	Wheat	Wheat	Bromus	Meadow	Oats	Corn *a*	Wheat	Meadow	Meadow	Wheat 1, bromus 1 or more, oats 1, corn 1 *a*.
	3	Wheat	Wheat	Timothy	Meadow	Oats	Corn *a*	Wheat	Meadow	Meadow	Wheat 1, timothy 2, oats 1, corn 1 *a*.
	4	Wheat	Wheat	Clover.	Oats	Corn *a*	Wheat	Clover	Oats	Corn *a*	Wheat 1, clover 1 or 2, oats 1, corn 1 *a*.
	5	Wheat	Wheat	*Clo. and Tim.	Meadow	Oats	Millet *a*	Wheat	Meadow	Meadow	Wheat 1, meadow 2, oats 1, millet 1 *a*.
	6	Wheat	Wheat	*Clo. and Tim.	Meadow	Oats	Corn *a*	Wheat	Meadow	Meadow	Control plot, same as No. 1, Series I.
	7	Wheat	Wheat	*Clo. and Tim.	Meadow	Oats	Mangles	Wheat	Meadow	Meadow	Wheat 1, meadow 2, oats 1, mangles 1 *a*.
	8	Wheat	Wheat	*Clo. and Tim.	Meadow	Oats	Rape *a*	Wheat	Meadow	Meadow	Wheat 1, meadow 2, oats 1, rape 1 *a*.
	9	Wheat	Wheat	*Clo. and Tim.	Meadow	Oats	Potatoes *a*	Wheat	Meadow	Meadow	Wheat 1, meadow 2, oats 1, potatoes 1 *a*.
	10	Wheat	Wheat	*Clo. and Tim.	Meadow	Oats	Sunflower *a*	Wheat	Meadow	Meadow	Wheat 1, meadow 2, oats 1, sunflower 1 *a*
	11	Wheat	Wheat	*Clo. and Tim.	Meadow	Oats	Corn *a*	Wheat	Meadow	Meadow	Control plot, same as No. 1, Series I.
II	1	Wheat	Wheat	*Clo. and Tim.	Meadow	Oats	Corn *a*	Wheat	Meadow	Meadow	Control plot, same as No. 1, Series I.
	2	Corn	Peas *b*	Barley	Clover	Corn	Peas *b*	Barley	Clover	Corn.	Corn 1, peas 1, barley 1, clover 1.
	3	Barley	Oats	Timothy	Meadow	Barley	Oats	Timothy	Timothy	Barley	Barley 1, oats 1, timothy 2.
	4	Barley	Oats	Timothy *y*	Timothy	Barley	Oats	Timothy *y*	Timothy	Barley	Barley 1, oats 1, timothy 2 *y*.
	5	Millet	Barley	Corn	Oats	Millet	Barley	Corn	Oats	Millet	Millet 1, barley 1, corn 1, oats 1.
	6	Wheat	Wheat	*Clo. and Tim.	Meadow	Oats	Corn *a*	Wheat	Clo. and Tim.	Meadow	Control plot, same as No. 1, Series I.
	7	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn in hills continuously.
	8	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes continuously.
	9	Mangles	Mangles	Mangles	Mangles	Mangles	Mangles	Mangles	Mangles	Mangles	Mangles continuously.
	10	Peas *c*	Peas	Peas	Peas	Peas	Peas	Peas	Peas	Peas	Peas, field, in drills, continuously.
	11	Wheat	Wheat	*Clo. and Tim.	Meadow	Oats	Corn *a*	Wheat	Meadow	Meadow	Control plot, same as No. 1, Series I.

*Timothy 8 lbs., red clover 6 lbs. *a* Eight tons stable manure per acre. *b* Sow broadcast. *c* Top dress with eight loads stable manure after cutting first crop of hay. *d* Dent corn, hills in ordinary way. *e* Plant field peas thickly in drills 30 inches apart. *y* Top dress timothy after mowing first hay crop.

TABLE CI. Continued.

Series.	Plot.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Rotation for Each Plot.
III	1	Wheat	Wheat	*Tim. and Clo.	Meadow	Oats	Corn *a*	Wheat	*Tim. and Clo.	Meadow	Control plot, same as No. 1, series I.
	2	Wheat *f*	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat continuously, fall; plow early.
	3	Wheat *g*	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat continuously; sow 6 lbs. red clover with wheat.
	4	Wheat	Wheat	Clover	Wheat	Clover	Wheat	Clover	Wheat	Clover	Wheat 1, clover 1; plow under second crop.
	5	Wheat	Wheat	Clover	Wheat	Clover	Wheat	Clover	Wheat	Clover	Wheat 1, clover 1; save second crop clover for seed or hay.
	6	Wheat	Wheat	*Tim. and Clo.	Meadow	Oats	Corn *a*	Wheat	Meadow	Meadow	Control plot, same as No. 1, series I.
	7	Wheat	Wheat	Pasture *j*	Pasture	Pasture	Pasture	Pasture	Pasture	Pasture	Wheat 1, permanent pasture *j*.
	8	Wheat	Wheat	Meadow *x*	Meadow	Meadow	Meadow	Meadow	Meadow	Meadow	Wheat 1, permanent meadow. *x*
	9	Millet	Millet	Clover *k*	Millet	Clover	Millet	Clover	Millet	Clover	Millet hay 1, clover 1, plow under second crop.
	10	Rape	Rape *l*	Rape	Rape	Rape	Rape	Rape	Rape	Rape	Rape continuously, drill, pasture off.
	11	Wheat	Wheat	*Tim. and Clo.	Meadow	Oats	Corn *a*	Wheat	Meadow	Meadow	Control plot, same as No. 1, series I.
IV	1	Wheat	Wheat	*Tim. and Clo.	Meadow	Oats	Corn *a*	Wheat	Meadow	Meadow	Control plot, same as No. 1, series I.
	2	Wheat	Wheat	*Tim. and Clo.	Meadow	Oats	Green Manure	Wheat	Meadow	Meadow	Wheat 1, *meadow 2, oats 1, green manure 1 *m*.
	3	Flax	Flax	*Tim. and Clo.	Meadow	Oats	Corn *a*	Flax	Meadow	Meadow	Flax 1, *meadow 2, oats 1, corn 1 *a*.
	4	Barley	Barley	Meadow *n*	Pasture	Pasture	Corn *a*	Pea Hay	Barley	Meadow	Barley 1, meadow 1 *n*, pasture 2, corn 1, field pea hay 1.
	5	Corn Soilage	Rye and Rape	Barley	Pasture *n*	Pasture	Pasture	Corn Soilage	Rye and Rape	Barley	Corn 1 *a*, rye and rape 1, barley 1, pasture 1 *n*.
	6	Wheat	Wheat	*Tim. and Clo.	Meadow	Oats	Corn *a*	Wheat	Meadow	Meadow	Control plot, same as No. 1, series I.
	7	Corn Soilage	Rye	Pasture *n*	Pasture	Pasture	Barley	Peas	Corn Soilage.	Rye	Corn 1 *a*, rye 1, pasture 3 *n*, barley 1, peas 1.
	8	Barley	Barley	Pasture *n*	Pasture	Pasture	Corn *a*	Barley	Pasture	Pasture	Barley 1, pasture 3 *n*, corn 1 *a*.
	9	Wheat	Wheat	*Tim. and Clo.	Meadow	Oats	Corn *o*	Wheat	Meadow	Meadow	Wheat 1, *meadow 2, oats 1, (tankage) corn.
	10	Wheat	Wheat	*Tim. and Clo.	Meadow	Wheat	Meadow	Meadow	Wheat	Meadow	Wheat 1, *meadow 2.
	11	Wheat	Wheat	*Tim. and Clo.	Meadow	Oats	Corn *a*	Wheat	Meadow	Meadow	Control plot, same as No. 1, series I.

f Fall plow early. *g* Fall plow early and seed in spring with the wheat 6 lbs. red clover per acre. *h* Plow under second crop, letting it seed first, if possible. *i* Save second crop for seed or hay. *j* Red clover, 3 lbs.; timothy, 4 lbs.; red top, 1 lb.; Kentucky blue grass, 7 lbs.; orchard grass, 3 lbs.; brome grass, 2 lbs.; alsike clover, 1 lb.; white clover, 1 lb. *k* Plow under second crop late in fall. *l* Plant in drills and weigh green crop; get at value by pasturing off like areas. *m* Plow under crop of mixed oats and millet early in summer, and late in fall a crop of rape. *n* Seed to timothy, 8 lbs.; red clover, 4 lbs.; alsike clover, 1 lb. *o* Tankage to equal the "commercial fertilizer" valuation of stubble manure used on check plots. *x* Red clover, 4 lbs.; alsike clover, 1 lb.; timothy, 4 lbs.; orchard grass, 7 lbs.; brome grass, 3 lbs.

ıtinued.

Series.	00.	1901.	1902.	Rotation for Each Plot.
	heat	*Tim. and Clo.	Meadow	Control plot, same as No. 1, series I.
III	heat	Wheat	Wheat	Wheat continuously, fall; plow early.
	heat	Wheat	Wheat	Wheat continuously; sow 6 lbs. red clover with wheat.
	over	Wheat	Clover	Wheat 1, clover 1; plow under second crop.
	over	Wheat	Clover	Wheat 1, clover 1; save second crop clover for seed or hay.
	heat	Meadow	Meadow	Control plot, same as No. 1, series I.
	sture	Pasture	Pasture	Wheat 1, permanent pasture *j*.
	adow	Meadow	Meadow	Wheat 1, permanent meadow. *x*
	over	Millet	Clover	Millet hay 1, clover 1, plow under second crop.
	ape	Rape	Rape	Rape continuously, drill, pasture off.
	heat	Meadow	Meadow	Control plot, same as No. 1, series I.
	heat	Meadow	Meadow	Control plot, same as No. 1, series I.
IV	heat	Meadow	Meadow	Wheat 1, *meadow 2, oats 1, green manure 1 *m*.
	lax	Meadow	Meadow	Flax 1, *meadow 2, oats 1, corn 1 *a*.
	a Hay	Barley	Meadow	Barley 1, meadow 1 *n*, pasture 2, corn 1, field pea hay 1.
	ı Soilage	Rye and Rape	Barley	Corn 1 *a*, rye and rape 1, barley 1, pasture 1 *n*.
	heat	Meadow	Meadow	Control plot, same as No. 1, series I.
	Peas	Corn Soilage.	Rye	Corn 1 *a*, rye 1, pasture 3 *n*, barley 1, peas 1.
	arley	Pasture	Pasture	Barley 1, pasture 3 *n*, corn 1 *a*.
	heat	Meadow	Meadow	Wheat 1, *meadow 2, oats 1, (tankage) corn.
	eadow	Wheat	Meadow	Wheat 1, *meadow 2.
	Vheat	Meadow	Meadow	Control plot, same as No. 1, series I.

der second crop, letting it seed first, if possible. *i* Save second crop for seed or hay. *j* Red clover, 3 lbs.; lb.; white clover, 1 lb. *k* Plow under second crop late in fall. *l* Plant in drills and weigh green crop; n fall a crop of rape. *n* Seed to timothy, 8 lbs.; red clover, 4 lbs.; alsike clover, 1 lb. *o* Tankage to equal l lb.; timothy, 4 lbs.; orchard grass, 7 lbs.; brome grass, 3 lbs.

during a number of years. The land is not thought to be as uniform in quality as is desirable. Plots 1, 2, 3 and 4, series 2, and plot 4, series 3, are in a slight depression which we suppose gives them the advantage of more moisture in dry seasons and somewhat richer soil. Below is given a general statement of the plan of work.

Plots 1, 6 and 11 of each series are designated as control or check plots, thus giving twelve plots all seeded to the same practical rotation. These are in three rows one extending along the east and one along the west of all the series and one through the middles, all running north and south. This plan distributs the control plots in such manner that the yields or profits on any plot can be compared with the average from all twelve control plots or with the averages from the several control plots immediately surrounding it On the twelve control plots the following plan of rotation has been instituted: Wheat is sown the first year, and with this crop the land is seeded down by sowing with the spring wheat six pounds red clover and eight pounds timothy seed. The second and third years meadow is grown and the fourth year oats. The fifth and last year of the rotation corn is planted, and the land previous to fall plowing the oats stubble under for the corn is given eight tons of barnyard manure per acre. Following the corn the wheat again begins the rotation of these same crops. These twelve control plots all being each year seeded to the same crop will give not only the average figures with which to compare the results of the different rotations, but will give also the range of variations due to the location of the plots in the field. These variations may prove very useful when summarizing the results of the experiments, and may show how great yields and profits must differ to show a decided superiority of one crop of one rotation over another.

Table CI. gives, in tabular form, the proposed rotation on each of the forty-four plots. The notes below the table give facts regarding grass mixtures, manuring and other special features of treatment. These rotations cannot be adhered to perfectly in this climate because of the occasional periods of drought which destroys the young plants of grass and occasionally of annual crops. The rotations are, as a rule, on a somewhat shorter plan than is generally practiced, possibly shorter than is wise. Just as in practical farming, however, they will be lengthened by the rather frequent failures to get catches of grasses and clovers, necessitating reseeding. Last year the very severe drought necessitates our again seeding many plots to annual crops with which to again seed down

to grasses and clovers. The effort has been made to try rotations suited to many specific purposes. And each rotation represents only one or a very few questions. It is found best to try only one experiment at a time and we have tried to avoid making the rotations so that each would endeavor to tell many things poorly, but one or a very few things well. These plans of rotations will doubtless be found very crude later on. Each series is so situated in the field that if desired other plots with more rotations may be added, and suggestions as to specific rotations for special purposes will be most thankfully received.

In another field seventy-two plots of three-twentieths acre each were planted to the following six crops, corn, wheat, flax, potatoes, mangels and field peas, twelve plots in duplicate of each. These crops extended in long belts across the field. Next year these same crops will be planted in long belts across the field at right angles to the direction of the belts last year. The yield was determined on each plot last year, and the yields will again be determined on each next year. This provides that each kind of crop will follow its own kind and each of the five other kinds of crops. Having the yields of each plot each year will give us facts as to the relative preparing effects each crop has for each other crop. In other words, it will show how each crop does when following each other crop.

The rotations outlined in Table CI each represent some particular feature or features in rotation of crops. Number 1, series I and other control plots are planted to a very practical rotation. Farmers will find numbers 3, 4, 5, 7, 8 and 9 in series I adapted to their varied uses, as also 2, 3, 4 and 5, series II, as also 2, 3, 4, 5, 7, 8, 9 and 10, series IV. Some other of the rotations will suit certain peculiar conditions, but most of them are here being tried to show what are not good systems of rotation.

To further get data for use in determining the relative profits from different crops and different rotations, the experiment station has started the collection of statistics as to prices of all feed stuffs and of meats and other finished products as sold off the farm and of the prices of farm labor. The State Bureau of Labor and Statistics is gathering many facts most useful in this connection. While results along the lines of experiments in field management will come slow, they should be of great value when finished. Clear knowledge on the part of our farmers during the early history of our state will result in a richer soil for coming generations to inherit.

SMUT IN WHEAT.

Wheat "bunt" or "stinking smut in wheat" has done great damage to the yields and quality of the wheat crop in the Northwest during the past year. Hon. A. C. Clausen, chief grain inspector of Minnesota, estimates that one-fourth of the wheat crop of 1894 sent to the general markets from the three states tributary to Minnesota's terminal markets was more or less affected by stinking smut. The trouble appeared mainly in the northern parts of these states.

A year ago this station published a bulletin calling attention to smut in wheat, and prescribed a remedy. Farmers had not awakened to the importance of remedial measures, but the indications now are that all are anxious to know the best means by which they can avoid loss from smutted grain. Millers and grain dealers are thoroughly aroused to the importance of preventing smut from injuring the yields, and especially the quality of our wheat and flour and the reputation of these commodities in domestic and foreign markets.

Treating wheat with blue stone or with hot water costs only a small proportion of the value lost in growing smutty crops, and these remedies are very effective. All seed wheat can be treated at a cost of one to three cents per acre. Blue stone of good quality may be purchased by grocers or druggists so that they can retail it to farmers at about ten to fifteen cents per pound. In Manitoba stinking smut was very prevalent a few years since; now very little of it can be found, as the farmers use large quantities of blue stone. At Brandon, Manitoba, alone, a town of a few thousand inhabitants, two or three carloads have been purchased for the year's demand.

Bunt or stinking smut of wheat is a disease caused by small spores. These are very small, seed-like, spherical bodies which are produced in the diseased kernels of wheat. These kernels are broken in threshing and handling the grain and the minute spores scattered about cling to the grains of wheat. When the seeds are planted the spores germinate much like small seeds, and some of them lying on

the kernel against the sprouting plantlet send their thread-like stems into the wheat plant. Here the disease thrives, branches, grows upward as the wheat grows, and when the wheat forms its seed some of the branches of the smut will have found their way into the kernels of wheat. Here it develops its seed like spores, and when the grain is ripe the diseased kernel of wheat is a mass of smut spores inclosed in the slightly enlarged wheat bran. These spores or germs live until the next year. If chance favors them they germinate on another young and tender wheat plant. These smut spores are very small and we cannot dislodge all of them from the seed grains by thoroughly cleaning the wheat. Some method of destroying them by heat or by the use of fungicides is necessary. During the past year we made experiments in the laboratory and in the field with fungicides and with heating the kernels both in hot water and in hot air. A thorough review has been made of the reports of experiments conducted at experiment stations in this country and in Canada and a number of reports have been received from farmers who have tried the remedy we advised a year ago and also other remedies. The blue stoning remedies and the hot-water treatment contain the essential principles used by all those who have successfully treated wheat for smut. So as we have learned, no one questions the effectiveness of the remedies or the profit of treating seed wheat. The blue stone sprinkling method is the handiest and cheapest of all and is nearly as good as any. The blue-stone dipping method is an old and tried remedy, kills the smut and is only slightly more expensive than the sprinkling method. Blue stone has a slightly injurious effect in retarding the germination of the grain, and the dipping method, as ordinarily carried out by farmers, has a worse effect than the sprinkling method. The hot-water treatment is the best in effect on the quality of the seeds and crop, and it destroys the smut, but under ordinary farm conditions it is somewhat difficult to carry out, as the wheat must be carefully dried, a rather difficult task in our cold spring weather.

Statements of all three methods are given below and farmers are urged to use that one which seems to them best suited to their conditions. It will pay every farmer to treat his wheat if there is any smut in the neighborhood. If everyone would treat his wheat, smut would probably disappear. But as long as there is any in the neighborhood the threshing machine will carry enough to each farmer to make treating the seed an annual necessity.

THE BLUE STONE SPRINKLING METHOD.

The blue-stone sprinkling method is the simplest and cheapest remedy we have tried. It is very effective and only slightly harmful to the seeds of wheat. Our own experience the past season, the ex-

perience of numerous farmers who have reported successful trials of this plan, and especially the strong words of commendation from Messrs. McKay and Bedford, superintendents of the Manitoba and Assinaboia Experiment farms, and from the farmers of those provinces where this plan has been generally adopted, all give us faith to recommend this method.

Remedy.—Dissolve one pound of blue stone (copper sulphate) in three gallons of water. Spread out ten bushels of wheat on a tight floor in barn or house or in a tight wagon-box and sprinkle on the solution. With scoop-shovel turn the grain several times during the sprinkling till every kernel is thoroughly wetted. The solution needs to penetrate even the hairs of the blossom end of each kernel and to penetrate the crease in the grain. In case of badly infested seed wheat it should be first thoroughly cleaned, using a strong blast to remove all grains of bunt and the three gallons of the solution should be applied to only seven bushels of wheat instead of ten. In three hours the wheat will be ready for the seeder and as the blue stone somewhat injures the seed it should not be prepared long before it is sown. A good plan is to prepare in the evening the seed to be used the next day. As the seed is somewhat swollen a few quarts more per acre should be sown than of dry wheat. The blue stone solution can be made by the barrel, using care to get the right proportions of blue stone and water, and then it can be measured out one ten quart pailful to seven or eight bushels of wheat. The wheat should be turned four or five times within an hour after sprinkling. If a water-tight floor is not available the solution should be sprinkled on so slowly that none runs through.

THE BLUE STONE DIPPING METHOD.

We have many reports from parties who have successfully treated smutty wheat by immersing it in solutions of blue stone. The effect is practically the same as with the sprinkling method. However, the grain is wetter and must be dried with care before it can be put in the seeder. This can be done by spreading thinly on the barn floor and shoveling over a few or several times daily until dry, or it can be accomplished by sprinkling land plaster or lime over the wet grain. Some have thought that the land plaster or lime has a beneficial effect, but experiments by other experiment stations fail to show that these substances have much value other than to dry the grain. By earlier absorbing the solution they may slightly lessen the evil effects the blue stone has on the germinating qualities of the grain. The following statement of this remedy contains the essential directions:

Remedy.—Fill a barrel two-thirds full of a solution of one-half pound of blue stone (sulphate of copper) to one gallon of water.

Partially fill gunny sacks with wheat and immerse in the solution for five or ten minutes, moving the sack up and down and shaking or kneading it so that every kernel is thoroughly wetted. Arrange a drip shelf on which to set the sacks of wet wheat that the solution draining out may run back into the barrel or hang them on hooks and catch the drip in pails. When the water ceases dripping out of the bags pour the wheat on the barn floor and shovel a few times daily till dry enough to sow, or if to be kept some days, dry thoroughly enough to store without danger of heating. The drying may be facilitated by mixing plaster or slacked lime with the wet wheat. It is necessary to renew the quantity of the solution, and for this purpose the prepared solution may be kept ready in other barrels.

THE HOT-WATER METHOD.

Professor Jensen of Denmark discovered that smutty wheat immersed in water heated to 130 to 135 degrees F. is not injured for seed, but that this temperature kills the germs of stinking smut. A higher temperature harms the wheat and a lower temperature will not kill all the smut spores. This treatment causes the wheat to germinate sooner than wheat not so treated, while the blue-stone methods, especially the dipping method, retard germination. In fact the hot-water treatment seems to have a decided, though small, advantage in increasing the yield of the crop. This is doubtless the best of the three methods where the farmer has facilities for perfectly carrying it out. But on most Northwestern farms it is very difficult to dry the treated wheat, and few have thermometers which are accurate enough to be relied upon at the temperatures named. By this method, if the drying is rapidly and thoroughly done, the seed may be prepared some days or weeks before the time of sowing.

Remedy.—Fill two barrels or washtubs two-thirds full of water. Keep the water in No. 1 at 120 to 130 degrees and No. 2 at 130 to 135 degrees. Fill gunny sacks, or bags of other open-meshed material, partly full of wheat; immerse in No. 1 till the wheat is warmed up so as to not cool the water in No 2; drain the bag a few seconds and then immerse in No. 2 for five minutes, raising and lowering the bag or kneading the wheat, so that the water thoroughly penetrates to and heats every kernel. Spread out at once and shovel over until dry. It is a good plan to dip the bag of wheat in cool water, so as at once to cool the wheat. Care must be taken to add hot water so as to keep the water in No. 2 at 130 to 135 degrees; 133 degrees F. is the temperature preferred.

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